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ABSTRACT

Presented is the report of a workshop to review the state-of-the-art and government plans for research, development, and deployment of personal systems for independent travel by the physically handicapped. Section I includes papers on the interest and role of Veterans Administration, Rehabilitation Services Administration, Department of Transportation, and Consumer groups. Section II provides six state-of-the-art papers covering such issues as automotive vehicles, automotive control systems, driver education and licensing, and driver performance. Section III consists of reports from the four panels. A final section includes the following attachments: an outline of the program, list of participants, list of vehicles and equipment displayed, a paper on the improved mobility package by Ford Motor Company, a Selective bibliography, and a list of adaptive automotive equipment manufacturers in compliance with Veterans Administration requirements. (SBH)

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PERSONAL LICENSED VEHICLES

FOR THE

DISABLED

Report of a Workshop
June 14-17, 1976

held at the

Skyline Inn
Washington, D.C.

Rehabilitation Engineering Center
Moss Rehabilitation Hospital
12th Street and Tabor Road
Philadelphia, Pennsylvania 19141
1976

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PREFACE

At the request of the Veterans Administration and the Rehabilitation Services Administration of the Department of Health, Education, and Welfare Interagency Committee on the Rehabilitation Engineering Center, Moss Rehabilitation Hospital organized and conducted a workshop on personal licensed vehicles for the handicapped for the purpose of reviewing the state-of-the-art and government plans for research, development, and deployment of personal systems for independent travel by the physically handicapped.

To provide guidance a Steering Committee composed of the following members was appointed:

Michael Boblitz
Harold Booher
Paul Brainin
E'lise Brown
Richard Herman
Maurice LeBlanc
Make McDermott
Raymond Pearson
Edward Peizer
Anton Reichenberger
Warren Smith
Anthony Staros
A. Bennett Wilson, Jr.

It was recognized by the Steering Committee that it would be desirable for the workshop to cover the problems of all categories of the physically disabled population, but realized that such would not be practical at this time. Accordingly four categories of patients were selected for consideration: amputees, hemiplegics, paraplegics, and quadriplegics.

The workshop was held in Washington, D.C. June 14-17, 1976. The 71 participants represented various specialities in engineering, medicine, and the allied health professions.

After an opening session in which representatives from the various government agencies that have responsibility for the mobility of handicapped persons set forth the responsibilities and roles of their respective agencies and a representative of the consumer group presented some of the problems of the disabled, most of the more advanced personal licensed vehicles were demonstrated.

The afternoon of the first day was devoted to a presentation on the state-of-the-art and a proposed plan for research, development, and evaluation for the next five years.

On the second and third days the group was divided into four interdisciplinary panels and asked to consider the problem with respect to the following matrix:

	Amputees	Hemiplegias	Paraplegias	Quadriplegias
Autos, Conventional				
Vans				
Powered Wheelchairs				
Special Systems				

On the morning of the third day each panel presented in plenary session a report of the previous days work, and reconvened to continue consideration of the problems presented the day before.

The closing session, on the morning of the fourth day, consisted of a presentation of consolidated panel reports and a general discussion.

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SYNTHESIS OF PANEL RECOMMENDATIONS

This section was developed at a post-workshop meeting of the Steering Committee by consolidating the reports of the individual panels. Most of the recommendations were proposed by more than one panel. The consolidated recommendations have been classified according to the major type of activity involved; that is, Administration, Research and Development, and Dissemination and Application of the Results of Research and Development.

The recommendations within each class of activity are listed more or less in priority, recognizing that in some instances certain actions must precede others, while in other instances projects can be started simultaneously and operated concurrently.

ADMINISTRATION

1. Strengthen the Interagency Committee so that it may provide plans and policy needed to make possible an efficient integrated program in research, development, evaluation, education, and delivery of systems and services.
2. Contract with a non-government organization for the administrative support of the total program.
3. Explore with the automobile manufacturers, possibly through the Society of Automotive Engineers, the establishment of standard design guidelines to meet the current needs of the disabled driver. A standardized attachment bracket for current conventional hand controls, standardized automobile floor and roof heights to facilitate wheelchair activities, and wider door openings are examples of subjects that should be investigated.

4. Establish and maintain a data bank consisting of basic and other information needed by research and administrative personnel.
5. Establish the current state-of-the-art of driving for the disabled as a basis for future research and development.
6. Promote legislation to clarify or properly define the product liability responsibility with respect to equipment for the disabled to protect manufacturers from unfair prosecution.

RESEARCH AND DEVELOPMENT

1. Develop standard procedures for assessment of the disabled. It is felt that a number of potential drivers, especially among those with brain damage, are being excluded from training programs because of inadequate assessment methods. Improved assessment methods will also result in a more efficient screening and training program.
2. Evaluate simulators used for driver evaluation and training, and if found lacking for the purposes intended, initiate a research and development program.
3. Develop standard driver education and training programs.
4. Investigate emergency-situation safety, including communications systems.
5. Design and develop electrically and manually operated wheelchairs so that they serve safely as either a driver's or passenger's seat for as many types of transportation vehicles as possible (i.e., urban and interstate public buses and trains). A powered wheelchair which folds for storage is needed. Requirements for access and egress must be borne in mind constantly.

Design, and develop a "universal" or standardized wheelchair securement or restraint system. The wheelchair restraint system should be applicable to as many types of transportation vehicles as is possible.

6. Evaluate servo-control designs. Redesign is probably necessary if they are to meet safety, reliability, and wear requirements. Also, it is preferable that new control equipment be designed and provided by automobile manufacturers instead of others.
7. Develop guidelines for application of adaptive equipment (whether added to driver or vehicle) for matching the functions of the physical system to the capabilities of the driver.
8. Explore vocational opportunities for disabled individuals as commercial vehicle drivers through specialized licensing.
9. Investigate the modular concept to mobility as set forth in the report "Mobility for Spinal Cord Impaired People."[1] Such a system recognizes all of the activities to be undertaken by an individual from the time he arises from bed in the morning until he retires at night.

APPLICATION OF THE RESULTS OF RESEARCH AND DEVELOPMENT

1. Develop and establish improved systems for delivery of equipment and services. Special regional centers should be established for handling the more complex cases and perhaps provide maintenance and inspection of equipment. Rehabilitation engineers should play a key role in the development and operation of these centers.

   Some of the major steps in establishing the special centers are:

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[1] "Mobility for Spinal-Cord-Impaired People - Report of a Workshop February 22-24, 1974," Committee on Prosthetics Research and Development, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418.

a. Establishment of multidisciplinary teams consisting of a physician, rehabilitation engineer, therapist, driver educator-trainer, and psychologist or social worker to carry out the assessment of disabled individuals to be drivers.

b. Implementation of an education program for members of the service team.

c. Dissemination of information to both lay and professional groups.

PURPOSE AND GOALS OF THE WORKSHOP

Richard M. Herman
J. Raymond Pearson

The importance of mobility to the disabled can hardly be overemphasized. It enables those deprived of the natural abilities of locomotion and upper limb and other normal functions to move about so that they can reach and engage in meaningful vocations, to participate in community affairs, to seek cultural and recreational outlets, to broaden the scope of their outlook and generally enrich their lives.

In order to stimulate effort to provide such mobility to those deprived of it, this state-of-the-art type of conference is being convened to establish guidelines for research and development and deployment of driving systems that permit the severely disabled to operate their own personal, licensed vehicles. It is the hope and purpose that the Conference will serve to inform those engaging in the effort of the current state-of-the-art, to identify research and development needs, and to encourage progress in bringing about solutions to the problems posed.

The broad scope of the problem ranging from the complexities of the neural and anatomical systems of the driver to the effectiveness and reliability of adaptive mechanical servo systems require expertise from the medical, paramedical and engineering disciplines. Present are representatives of the rehabilitation research community, the community of the disabled, the adaptive systems manufacturers, the automotive industry, and the government.

The deliberations, discussions, and demonstrations of these representatives should lead to recognition of the various factors that need attention. Among these are the human factors of driver capability; the biomechanics of strength, range of motion, and control; driver training and driver site design. The mechanical characteristics of adaptive systems necessary to match driver capability; the technology of design, manufacture, installation, and maintenance are to be considered. Safety of the driver, passenger, and other motorists, and associated legal matters of licensing, liability, and insurance are also to be given due regard.

Expressions of appreciation are due the officials of the Veterans Administration and the Rehabilitation Services Administration of the Department of Health, Education, and Welfare for making the Conference possible.

It is expected that the report of this workshop will guide and help those who can and will to provide safe and convenient systems to increase the mobility of the disabled, and thereby enable them to undertake vocations and avocational activities otherwise denied them by force of circumstance.

SECTION I. INTEREST AND ROLE OF:

VETERANS ADMINISTRATION

REHABILITATION SERVICES ADMINISTRATION,
DEPARTMENT OF HEALTH, EDUCATION,
AND WELFARE

DEPARTMENT OF TRANSPORTATION

CONSUMER GROUPS

DISABLED VETERANS' AND SERVICEMEN'S AUTOMOBILE ASSISTANCE ACT OF 1970 AND ITS IMPACT

Arthur J. Schultz, Jr.

As a student of engineering and with involvement in the automobile manufacturing business, and especially because of the Veterans Administration's role in serving those who served, particularly the severely disabled, I am pleased and grateful to be able to participate in this most important "Workshop on Personal Licensed Vehicles for the Physically Disabled."

It is my privilege this morning to address what has to be the most diversely talented group of national leaders in all phases of automotive transportation that has ever been assembled at one time in one place.

Although I do not presume to be able to add to the specialized knowledge and expertise that you bring to this conference, individually and collectively, I can tell you something about the advances that have been made in the past five and a half years alone in providing physically disabled veterans with the safest and most sophisticated and helpful automotive adaptive equipment, and in training them to use this equipment.

I say veterans deliberately, because their welfare is the concern and responsibility of the Veterans Administration. All of us know, however, that medical and prosthetics research and advances, including, of course, adaptive equipment, help not only physically disabled veterans but all physically disabled persons. And for this all of us are grateful.

Immediate post World War II programs provided the disabled veteran with a lump-sum payment to purchase an automobile, but there was no special allowance for adaptive equipment.

But in June 1971, the adaptive equipment program was given a major forward thrust with the enactment of Public Law 91-666, the "Disabled Veterans' and Servicemen's Automobile Assistance Act of 1970." This law increased the maximum amount of VA monetary assistance for the purchase of an automobile or other conveyance by a veteran, who is service-connected disabled in such a way as to have lost, or lost use of, one or both hands or feet.

The Senate committee report on this legislation stated that adaptive equipment on automobiles for disabled veterans was in the nature of prosthetic appliances, which were provided by VA on a continuing basis to service-connected disabled veterans as part of medical treatment. It expressed the view that a one-time allowance for adaptive automobile equipment did not meet the continuing need of the disabled veteran. Thus, the committee substituted a requirement that such devices shall be provided on a continuing basis.

This was a good law that had two major objectives: first, to make available adaptive driving devices to handicapped veterans who might then be able to operate motor vehicles; second, to require the establishment by the Veterans Administration of safety and quality standards for adaptive equipment.

To carry out the 1970 Act, VA established four priorities that provided for:

1. The furnishing of the grant toward the purchase of the vehicle.
2. The furnishing of adaptive equipment to eligible beneficiaries.
3. The furnishing of repairs, replacement, or reinstallation of adaptive equipment.
4. The development of standards of safety and quality.

It was possible to achieve the first three objectives while proceeding to develop standards of safety and quality. Accordingly, directives and forms were prepared by the Department of Veteran Benefits, the Controller, and the Department of Medicine and Surgery to advise all VA field stations of the procedures to be employed in the administration of Public Law 91-666.

In December 1974, Congress enacted 93-538, the "Disabled Veterans' and Servicemen's Automobile and Adaptive Equipment Amendments of 1974." It broadened the VA adaptive equipment program's base and accomplished several important objectives, including:

1. Widening eligibility.
2. Mandating establishment of a driver training program.
3. Increasing the VA monetary allowance from $2,800 to $3,300.

To return to the 1970 act, Congress recognized that the establishment of standards had to await the accumulation of experience and that in the meantime the question would be resolved by the judgment of the certifying official.

The Department of Medicine and Surgery in the Veterans Administration identified prosthetic representatives and/or designated

physicians at VA hospitals and outpatient clinics as certifying officials.

In May 1971, the VA Prosthetics Center in New York City instituted procedures to allot space and existing staff to the standards-setting program. Laboratory instrumentation and an investigation into the relative merits of the two known driving simulator systems were begun.

The Aetna Driver Trainer was later purchased and installed. It is used for evaluating the effectiveness of the various adaptive driving aids. Then, in conjunction with a computer, it yields data on patient requirements to operate these devices in the safety of the laboratory under simulated driving conditions of increasing hazards as the tests progress.

In November 1971, the Adaptive Equipment Committee was established. The committee was assigned responsibility for reviewing proposals for minimum standards of safety and quality as well as other functions pertaining to the administration of the program.

Beginning in December 1971, the VA Prosthetics Center submitted periodic progress reports to the Adaptive Equipment Committee. Telephone and visit contacts were constantly maintained during this period. Liaison was also maintained with the Department of Transportation, the Department of Health, Education and Welfare, state licensing agencies, the American Automobile Association, the Paralyzed Veterans Association, and Texas A&M University, where an automotive research project is being conducted under the auspices of the Department of Transportation.

Contact was also made with leading authorities at other universities. By July 1973, a first draft of the proposed standards was sent to the Interdepartmental Adaptive Committee for review. Numerous technical and administrative changes were incorporated into subsequent drafts.

In May 1974, a VA-appointed Ad Hoc Advisory Committee, composed of experts from various groups in industry and veterans organizations, met to review the fifth draft. This was then sent with some final minor modification to the Administrator of Veterans Affairs for approval.

To accompany these standards, an Action Plan was developed to coordinate the roles of various VA departments and offices in carrying out their assigned functions. The Action Plan recognized the need to make available clear and explicit standards as rapidly as possible. It also recognized the relationship of VA to the industrial community which had produced these items. And it allowed time to adapt to the new standards as they were developed.

Finally, the Action Plan took notice of the fact that only when severe structural or operational shortcomings of equipment were uncovered by testing was VA compelled to notify all veterans who were utilizing the equipment.

The Action Plan was divided into three phases.

Phase I, lasting eight months, was set for the testing and evaluation period, including the purchase and installation of testing equipment at the VA Prosthetics Center.

Phase II was an 18-month grace period to permit and assist manufacturers to modify and redesign equipment to meet VA's specifications.

This also permitted dissemination of standards of information to veterans who were using the equipment.

Let me emphasize that most manufacturers have met the standards set, either initially or after required modifications were made. The very few who have not will not have their equipment approved by VA for use by physically disabled veterans.

In fact, on April 3, 1975, by notice in the Federal Register, VA informed all concerned that after January 1, 1976, equipment that did not meet the Standards of Adaptive Equipment cannot and will not be furnished by VA.

Finally, Phase III of the Action Plan, to be conducted in January 1977, permits complete replacement of equipment to meet the new and upgraded explicit standards.

On a related front, VA is moving ahead rapidly with its driver training program for physically disabled veterans. Although the training of handicapped drivers dates back to World War II, the current impetus was developed by Public Law 93-358.

Under the new expanded program, 18 VA hospitals are currently engaged in driver training programs. These programs are conducted by corrective therapists who have taken special training courses given at leading universities.

The number of VA hospitals offering driver training to handicapped veterans will ultimately be expanded to more than 100.

I think it can be concluded fairly that the ability of the Veterans Administration to provide eligible veterans with tested and

standardized equipment for adaptive functions so as to operate motor vehicles in a safe and comfortable fashion is in compliance with the expressed will of the Congress.

We feel that this most important program is on target and will meet its objectives in the prescribed period of time.

It has been a privilege to participate in this workshop, with the invaluable opportunity it provides for the concurrent exchange, the cross fertilization of ideas and experiences in the broad and crucial area of automotive adaptive equipment and training.

On behalf of the deserving, disabled veterans to whom you have given new dimensions of mobility, and thus new means of enjoying productive, useful and happy lives, the Veterans Administration thanks you.

PROBLEMS IN PROVIDING SELF-RELIANCE IN TRANSPORTATION FOR DRIVERS WITH PHYSICAL HANDICAPS

Anthony Staros

Relatively speaking, only a short time has elapsed since we in the Veterans Administration first explored the problem areas we were likely to encounter in providing vehicles, automobiles and vans, for drivers with physical handicaps. And, indeed, as one might expect, to achieve our goal of providing this much-needed measure of self-reliance in transportation, formidable problems had to be overcome. Unfortunately, some of these problems have not been solved, merely scaled down. And much is left to do.

It was natural that our first priority was to insure the safety and reliability of the braking and speed controls developed and built by various commercial concerns as adaptations specifically intended for handicapped drivers. This is still a problem area. While we have made progress by formulating new reliability standards for adaptive automotive equipment for handicapped drivers, there are thus far no fool-proof methods to insure fully the quality of installation of these devices. However, advanced vehicle control systems based on servomechanisms may improve this situation materially in the future.

Our new reliability standards also cover access and egress systems for the severely handicapped driver. But, here too, the problem of guaranteeing the quality of installation has been, and still is, a difficult one to solve. However, in this case, the monitoring possibilities are more promising.

At the present time, we are taking a close look at several types of vans and super vans. The advantage of using these vans is that they make it relatively easy for the severely handicapped to enter or leave a vehicle. In addition, vans provide an excellent means of transportation.

When you have the responsibility of placing a handicapped person in a high-speed vehicle, either as the driver of that vehicle or simply as a passenger, you tend to worry about things. I must confess, we in the VA are chronic worriers. We constantly ask ourselves bothersome questions:

- How high up on the functional disability scale do we go? Where do we stop in our quest to accommodate the more severely disabled with independent transportation?
- Do we allow a client to use his own wheelchair as a vehicle seat? If so, how do we improve its design to make it safe as well as more functional?
- Should we develop intermediate-range vehicles as well as long-range vehicles?
- Do we design short-range powered wheelchairs for all types of terrain?
- What about using compact vehicles for the handicapped?
- And as we provide these new capabilities for those who until now have been completely dependent on others for their transportation needs, can we also provide them with new employment opportunities?

These are but some of the questions we should consider. I'm sure there will be more. But before we delve into the details posed by these questions, let us pause briefly, take a look around and see where we are, and in which direction we've started to go. The exhibit later on this morning will serve this function, giving us an opportunity to examine some examples of the present effort. Afterwards, we will hear reviews of the state-of-the-art, and our plans thus far for an inter-agency research, development, and evaluation program. Then during this week we expect to come up with some specifics about the direction we should follow for the next five years.

In the process, we hope to attract the interest of talented, innovative people in our program, those already involved in helping the handicapped, and those who are not now so involved but who have special talents and capabilities we need, so that perhaps five years from now we may observe significant improvements in personal vehicle design, not only those which benefit the handicapped driver, but also those which may benefit drivers in general.

HANDICAPPED MOBILITY CONCERNS OF THE REHABILITATION SERVICES ADMINISTRATION

James Garrett

In the Spring of 1975 an interagency agreement between the Veterans Administration and the Rehabilitation Services Administration was signed which read in part: . . . "cooperation between the Rehabilitation Services Administration and the Veterans Administration will range from interagency review of applications, routine interchange of research findings, and where indicated joint sharing in the cost of funding mutually supportive research, demonstration, evaluation, utilization, and other research related activities. The purpose of this multi-level and interrelated communication structure will be to generate, from the 'bottom-up,' major research issues of mutual interest to both agencies."

This workshop on Personal Licensed Vehicles for the Disabled is an excellent example of the kind of interagency cooperation and coordination intended by the formal agreement. Fortunately, representation in this workshop goes much further by including other key agencies, such as the Department of Transportation, the Food and Drug Administration and many others to provide a forum for Government, industry, voluntary organizations and consumer groups to discuss this major concern in greater depth.

From the standpoint of the Rehabilitation Services Administration basic issues that should be discussed in your deliberations should include: 1) overall needs of various disabled population groups with respect to personal licensed vehicles; 2) prioritied research requirements

to fill knowledge gaps; 3) strategies for the installation and maintenance of adaptive equipment and training of handicapped individuals in its use; and 4) incentives to encourage industry in the development, production, marketing and distribution of improved and innovative systems to broaden the independence potential of handicapped individuals.

Recent investigations such as the Comprehensive Needs and Sheltered Workshop studies have shown that one of the most serious barriers to the employment of handicapped persons is transportation. Strong suggestions were made in the comprehensive needs study that research in this significant area be pursued vigorously to overcome this impediment to complete rehabilitation.

We extend very best wishes for success in your workshop. The proceedings will undoubtedly represent a significant contribution to industry as well as governmental and nongovernmental agencies and organizations in planning future research, development, and deployment in this field, but most of all to the disabled themselves.

EFFORTS OF THE DEPARTMENT OF TRANSPORTATION TO IMPROVE TRANSPORTATION FOR THE HANDICAPPED

Ira Laster, Jr.

I appreciate the opportunity to appear before you today on behalf of Assistant Secretary Judith T. Connor to share with you some of the things we are doing in the Department of Transportation, generally with respect to the disabled and more specifically with respect to personal mobility of the physically handicapped.

DOT INDIVIDUAL MOBILITY ACTIVITIES

The Department of Transportation's activities to improve transportation services for the handicapped and elderly have been directed primarily at making transportation systems accessible to these population groups. However, for a little more than two and a half years, the department has received inquiries from individuals and institutions about possible financial assistance for support of research and development aimed at designing, building, and evaluating individual mobility devices or pedestrian aids which can be used by severely disabled individuals to enable them to move about, either under their own auspices or with minimal assistance from able-bodied attendants. The types of individual mobility devices for which aid has been sought include: powered carts and wheelchairs with special control switches, automobiles that have been modified so as to accommodate drivers who desire to remain in their wheelchairs while driving, and wheelchairs that will climb and descend stairs.

As a result of the inquiries mentioned above, together with a general awareness and concern among departmental officials that we have a

responsibility to provide safe, efficient, and convenient transportation for as many of the population as can effectively utilize it, a departmental task force was formed to examine whether and to what extent the department should become involved in activities to facilitate mobility of individuals, as distinguished from the features of transportation systems which accommodate the systems to such individuals. The task force's first assignment was to determine whether the department had the legal authority to deal with the problem of mobility of individuals; second, to examine the dimensions of the problem; and third, to assess what has already been done in this area.

Our present view is that we want to be helpful to the Veterans Administration (VA) and the Department of Health, Education, and Welfare (HEW) in their efforts with respect to individual aids, while we continue our efforts with respect to transportation systems and the accessibility to these systems. In some cases, we might be undertaking research on individual aids in selected cases, primarily in relation to transportation systems (e.g., how viable is a stair-climbing wheelchair as an alternative to an elevator or an inclinator in a subway station?). We would also hope to continue to be of assistance to the VA and to HEW with respect to their efforts regarding safety of devices for handicapped in automobiles.

ACTIVITIES OF THE U.S. DOT TO IMPROVE TRANSPORTATION FOR THE HANDICAPPED

The Department of Transportation's first major action to improve transportation for the physically handicapped occurred in 1969 with the funding of a study of the transportation needs of the handicapped. The study, which was conducted for the department by Abt Associates of Cambridge, Massachusetts, represented the first serious attempt to identify

barriers to travel by the mobility limited, and to recommend approaches to overcoming those barriers. The study report, entitled *Travel Barriers: Transportation Needs of the Handicapped*, has been widely circulated among improving transportation services for the handicapped.

Since release of the travel barriers report in 1969, the department has supported a variety of research and demonstration projects aimed at making public transportation more accessible to and usable by the mobility limited. Research and development activities have focused on equipment design, and the modification of related facilities aimed at eliminating barriers which impede mobility in those modes of transportation for which the department has a responsibility.

URBAN MASS TRANSIT

The element of the Department of Transportation which has the largest responsibility for improving transportation for the handicapped and elderly is the Urban Mass Transportation Administration (UMTA). Among other things, UMTA has supported research oriented toward identifying the physical demands that use of public transportation makes upon the handicapped and elderly. Findings from this research are being used to determine how best to modify transportation equipment facilities so that they are accessible to and usable by severely disabled individuals. In addition, UMTA has supported a variety of demonstrations aimed at discovering new service approaches for responding to the special needs of the handicapped and elderly.

Perhaps the most significant action that UMTA has taken recently is the issuance, on April 30th of this year, of advisory guidance indicating that special consideration be given to the needs of the handicapped

and elderly in the areas of planning, service strategies, facilities construction and modification, and equipment selection. We anticipate that this advisory guidance will assist transit operators in responding to the special needs of the handicapped and elderly.

AIRLINE TRAVEL

With respect to air travel, the Federal Aviation Administration within the Department of Transportation has published an *Airport Medical Design Guide*, which, if used in conjunction with a previously published advisory circular on eliminating barriers in airport terminals, provides the airport operator with the necessary information for designing airports which are fully accessible to the physically handicapped. FAA has a rulemaking action under review directed toward developing uniform safety criteria for transporting mobility restricted persons in civil air carriers. FAA expects to finalize the rulemaking process by issuing a safety regulation, together with an advisory circular setting forth training requirements for airline personnel on how to respond to the special requirements of disabled travelers.

RAIL TRAVEL

The Federal Railroad Administration is working cooperatively with Amtrak to assure that new equipment and new or renovated terminals include provisions for facilitating movement of mobility limited persons.

PEDESTRIAN AND VEHICLE DRIVING SAFETY

The National Highway Traffic Safety Administration (NHTSA) has broad responsibilities in the areas of pedestrian and vehicle driving safety. Through its Traffic Safety Office, NHTSA seeks to aid the states in implementing safe and effective driver licensing and driver education

programs and standards. There is now a national standard which calls for each state (with at this time three exceptions: Alaska, Idaho, and one other) to have a medical advisory board which establishes medical criteria for licensing drivers and which reviews individual cases referred by the driver licensing agency. In recent testimony before the National Commission on Epilepsy, we emphasized the need for a public education program and special training for driver licensing. These state medical advisory boards can provide the means to promote special licensing programs for the handicapped. The work of medical advisory boards should however be backed-up by a strong research base. In attempting to meet this need, NHTSA has already initiated an R&D program to (1) determine the impact of handicapped drivers and traffic safety, and (2) to design a five-year R&D program to develop licensing procedures for state handicapped licensing activities.

LICENSURE OF PERSONAL VEHICLES

During the past several years we have received inquiries from handicapped individuals seeking our assistance in acquiring a license which would enable them to operate powered carts and modified electric wheelchairs on public streets and roads. Since the licensure of drivers and vehicles is primarily a state responsibility, we have referred all such inquiries to those appropriate state department of motor vehicles.

As I see it, the Department of Transportation would play a minimal role in licensing drivers and powered vehicles for use on public streets and roads. The department would, however, have major responsibility for ensuring that powered vehicles licensed to operate on public streets and roads meet appropriate safety standards for both the vehicle and its operating environment.

SOME PROBLEMS OF THE CONSUMERS

Larry Ross

As Executive Director of the Paralyzed Veterans of America, I would like to express my appreciation to Moss Rehabilitation Hospital and the Veterans Administration for asking me to participate in this seminar as a consumer representative. I would also like to welcome all of the visitors to Washington, D.C. On behalf of the PVA National Office located here, I offer you any assistance you may require during your stay.

Since safety has already been covered by previous speakers, I will mention four other attributes which must be apparent before privately licensed vehicles become a part of the disabled's life.

Adaptive devices and vehicles must be functional, usable, available and economically feasible. Obviously, several of these attributes have not been realized or this outstanding group of specialists and professionals would not be gathered here today.

Yet, to me, the intra-agency and multidisciplinary composition of the participants in this seminar represents a tremendous step in the progress of understanding and concern for the needs of the disabled population in our country. Only last year, I believe, such cooperation would have been almost impossible. Therefore, as a consumer, I want to express my thanks to this distinguished group for your interest, concern and willingness to work on the problems facing people with physical disabilities.

Many of you are engineers and scientists. May I, as a consumer, ask that you not create too much without involving disabled

individuals in your efforts. Too often, I believe, things created by the non-disabled tend not to meet the needs of the disabled. Ivory tower inventions developed to specifications involving theoretical limitations may have nothing at all in common with a particular quadriplegic who wishes to enter society. Samples of individuals from real groups of disabled individuals should be used. Too often, the consumers have seen devices reach the market without having really been tested by those for whom use was intended.

Another point I would like to make has to do with the process all of us here intend to define. Almost everyone in this room earns his or her living working in an area touching the lives of a handicapped population. Many of you will retire while doing similar work.

Occasionally, we, the consumers, see the process inherent in efforts designed to assist us become more important than the purposes for which the process was initiated. Persons can live and die in jobs created by the needs of the physically disabled; and the disabled individual is often lost in the red tape and complexities created by workers, specialists and professionals developing and protecting their own livelihood. To some extent this may be unavoidable; however, we can and must occasionally remind ourselves and our counterparts what goals we are working toward. We must maintain that knowledge that people are waiting, in need, of our progress.

The greatest wisdom of the science we are here to discuss emanates from our basic desire to help people. I ask that this desire not be forgotten. No one would deny that in the United States a national

social concern is to help all minorities become a part of the society; however, when individuals in this society are approached, they sometimes shy away from obligation by lauding their indirect effort. When this seminar ends and we go our own ways, please remember that as a group of individuals we decided our future direction and as individuals we must continue that direction.

Again, thank you for inviting me to participate and thank you for listening.

SECTION II. STATE-OF-THE-ART PAPERS

AUTOMOTIVE VEHICLES FOR THE HANDICAPPED

Edward Peizer

Automotive control systems such as the Lunar Rover Control, the Sevier Control, and the CCI-Harden Control do not represent the state-of-the-art today. Some are experimental; others are developmental, there being only a few models currently available for evaluation. Perhaps these new systems will represent the state-of-the-art from one to five years in the future.

In use today are mechanical systems consisting for the most part of rods and fasteners to link levers mounted near the steering wheel to the accelerator and brake pedals for manual operation. The vehicles in use today are principally conventional sedans, usually of the larger sizes. Wheelchair users prefer large vehicles to facilitate transfer from a wheelchair and storage of the chair behind the driver's seat. Handicapped people who must or prefer to use electrical wheelchairs, which are not readily foldable and hence not easily placed in a car, generally use vans. These otherwise conventional vans are usually equipped with an elevator system for entry and exit and some means for stabilizing the driver while seated in the driving position. Except for the Scott van, which is equipped with a joystick and a servo-control system, they use mechanical systems.

In a very real sense then there are no vehicles available that have been designed especially for the handicapped. We have sedan-type vehicles adapted for use by handicapped persons who have near normal use of their arms, and we have vans modified to enable handicapped people in

wheelchairs to enter, drive, and exit independently. As these systems are refined and as new developments enter the main stream of available technology, we may see quite different vehicles designed specifically for the handicapped.

As technology improves, it is to be expected that handicapped persons with increasingly severe physical limitations will be driving. Practically, we must take a conservative view of the potential safety hazards to the driving public and to the handicapped driver himself. For the moment we can only say that as technology permits, and as the best assessment techniques indicate, everyone who can, should be enabled to drive. In this connection, however, a great deal must be done in the area of assessment of the severely handicapped population, including those with sensory deprivation, epilepsy, etc.

I should like to point out that neither I nor, in my opinion, anyone else today know the full state-of-the-art as it concerns vehicles, control systems, access systems, automotive seating, tie-down systems, driver assessment, and training and evaluation for the handicapped driver. In these areas we have had some experience which we will share with you this afternoon. This is a rapidly changing field and it seems that hardly a week passes without information and literature reaching us about some new device for the use of the handicapped in driving. Much of what we discussed, therefore, will represent the state-of-the-effort as well as the state-of-the-art. I will discuss vans, automotive seating, unconventional vehicles, and experimental devices. Mr. Reichenberger, who follows me, will discuss the currently available control systems, and Mr. Booher and Mr. Brainin who follow him will discuss other areas

from the standpoint of the responsibilities of the Department of Transportation.

VAN PROGRAM

Our experience in this field began in early 1972 very shortly after the passage of Public Law 91-666. Our early efforts centered around the safety of hand control systems which Mr. Reichenberger will discuss. During 1972 and 1973 we became aware of the increasing use of vans and the early development of the Scott van for severely handicapped electric wheelchair users. By the end of 1973 we had received a great deal of word-of-mouth information, unconfirmed reports, and literature on the use of vans. Neither this information nor our limited experience with one or two vans permitted us to draw valid conclusions about the proper utilization of vans and accessory components. We learned of the availability of approximately a dozen different types of vans. This made us realize that only a systematic approach to the study of all available van configurations would permit us to develop prescription indications, safety requirements, and acceptable standards of function and comfort.

In compliance with Public Law 93-538 and in an effort to meet the needs of the more severely handicapped veterans, we initiated a van evaluation program. Its purposes are:

1. To obtain field experience on the relative merits of all of the available van systems with particular respect to access systems, driving control, roadability, convenience of various features for individual and family use.
2. To develop government standards of safety, quality, and durability governing the purchase of vans by veterans under beneficiary entitlements.

3. Clarification of prescription indications for various types of vans.

4. To enable qualified veterans to learn to drive, take licensing tests, and to give them experience in the use of a variety of van configurations to help them select the most appropriate vehicle for themselves (see Appendix A).

The plan called for the deployment of all the major variations in types of commercially available vans. Although some 10 to 12 distributors were identified, each of their products seemed to represent a minor variation of what we considered to be four basic types:

1. Drivemaster (Figures 1 through 4)

   Access to the vehicle is provided by a side-loading elevator which rotates approximately 180 degrees. The elevator is controlled as are the others, from points both outside and inside the van. The elevator is stored in the cargo space of the van. Conventional mechanical hand controls are used for driving.

2. Roycemobile (Figures 5 through 8)

   The Roycemobile is also entered from the side. The elevator ramp is a structural part of the van. The user lowers the elevator, drives his wheelchair on to it, raises the elevator completely and, in effect, closes the "side door." The elevator platform does not occupy cargo space but the motor and housing do. One unique feature of this system is the driver's seat which is designed so that the user may

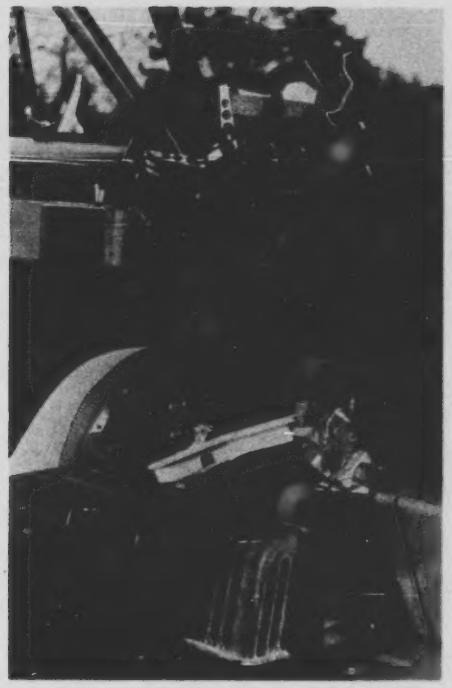


Figure 1. Drive-Master Van -
Driver Area.

Figure 2. Drive-Master Van -
Side View with Lift.

Figure 3. Drive-Master Van - Driver Area.

Figure 4. Drive-Master Van - Side View with Exterior Controls.

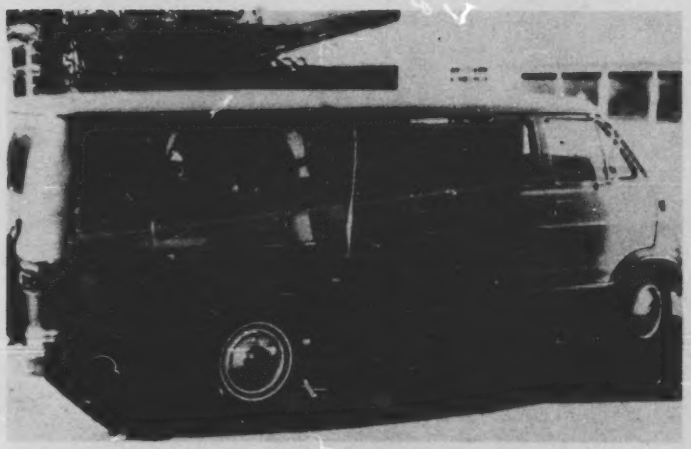


Figure 5. Roycemobile - Side View.

Figure 6. Roycemobile - 3/4 Side View.

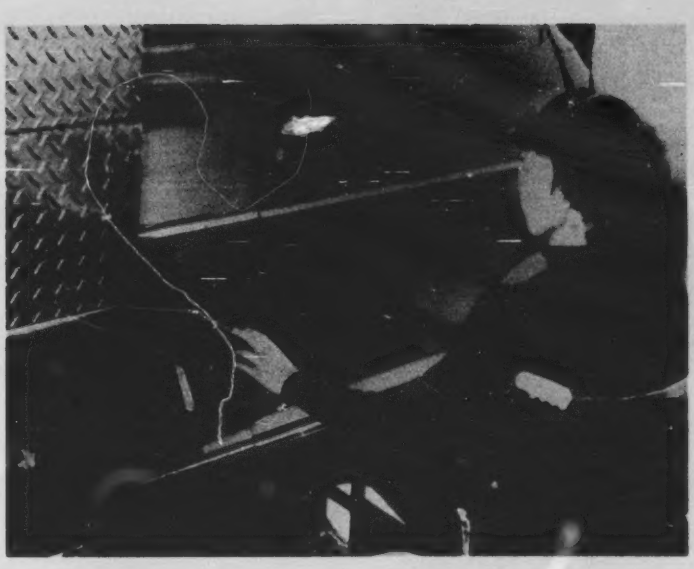


Figure 7. Roycemobile - Side View with Exterior Controls.

Figure 8. Roycemobile - Driver Area.

transfer from his own wheelchair. A little later we will discuss the question of driver seats.

3. Motorette (Figures 9 through 12)

   The Motorette is entered from the rear. Its elevator is available as a component of the Motorette van available from the Motorette Corporation and it may also be purchased separately for installation in other vans.

4. Scott (Figures 13 through 17)

   This van is quite different from the three previously shown in that it represents the archetype of a vehicle designed especially for the handicapped. The others are commercially produced vans modified by the addition of hand controls and and elevator system. The Scott van is of the rear-loading type and its most unique feature is the servo-control that is actuated by use of a joystick. The ignition and the operation of all accessories, including lift and rear doors, are accomplished by actuating push buttons mounted on a panel facing the driver. Acceleration is accomplished by pushing the joystick forward; braking is accomplished by pulling to the rear. Rotation of the small wheel steers the vehicle.

In our evaluation program we have deployed several models of each of these vans as well as several models of five other vans which are essentially similar to the Drivemaster, Roycemobile, and the Motorette. These are the Helper, Speedy Wagon, the Braun, the Compass and the Sevier vans. Approximately 40 patients have completed courses of training which

Figure 9. Motorette Van - Side View.

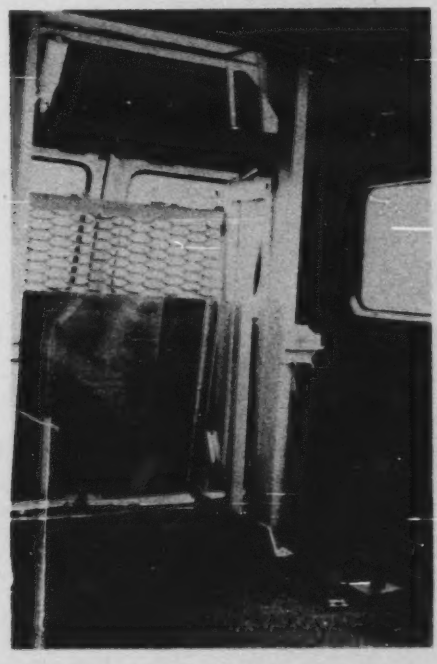


Figure 10. Motorette Van -
Rear Interior View with Lift.

Figure 11. Motorette Van - Rear View with Exterior Controls.

Figure 12. Motorette Van - Side View with Wheelchair as Driver Seat.

Figure 13. Scott Van - 3/4 Side View.

Figure 14. Scott Van - 3/4 Rear View with Lift.

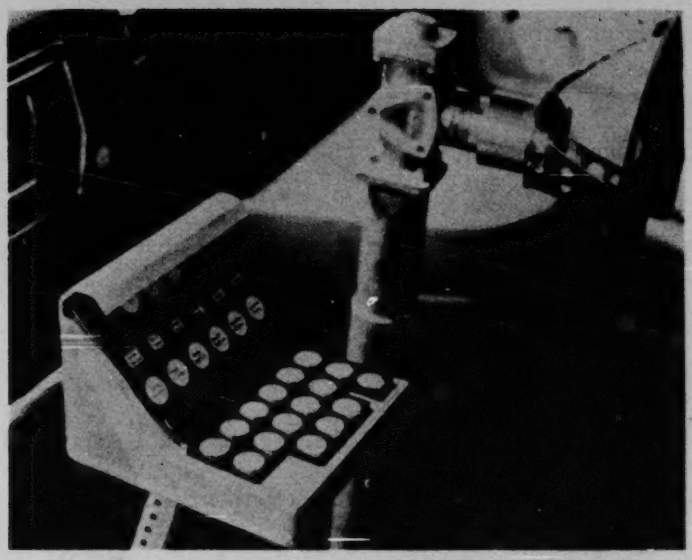


Figure 15. Scott Van - Front Interior View of Servo-Control and Accessories Panel.

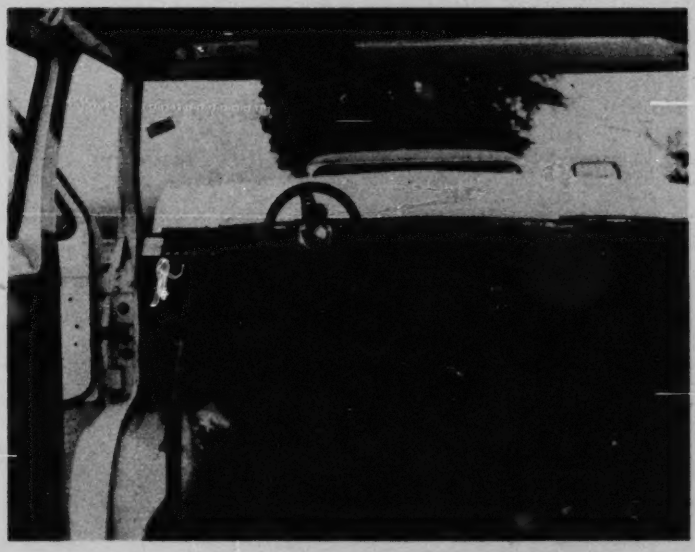


Figure 16. Scott Van - Front Interior View of Driver Area.

would qualify them to take state licensing examinations with this equipment. Despite the extensive modifications, and the large number of special features used in these vans, their use by patients entails an extensive series of steps.

The study is far from complete. The deployment of vehicles is essentially complete and the intensity of the training in each station is now increasing. We expect the program to tell us a great deal about the utility for specific users of rear loaders, side loaders, seating arrangements for driving, and a certain amount of information on hand controls. From preliminary reports it is already becoming clear that all vans should have raised roofs to facilitate entry and better windshield vision. Tie-down systems for both drivers and passengers need improvement.

TESTING PROGRAM AT TEXAS A&M

As we gain more information through the use of vans in VA hospitals, Texas A&M University is conducting a test program under VA contract. Included are a van lift test program, an evaluation program of several developmental servo-control systems, and both engineering and human factors analyses on the total configuration of each van system.

VAN LIFT TEST PROGRAM

During the past year, 10 different van lifts have been extensively tested by Texas A&M employing a rigorous procedure, including analyses of:

1. basic design and method of operation.
2. required action and decisions by driver and passengers.
3. possible driver and passenger errors.

4. hazards to driver and passengers.

5. acceleration imposed upon occupants.

6. angular positions of lift platform.

7. maximum lifting capacity.

8. esthetic and general design attributes.

The lift test program has reached the point where the group at Texas A&M feels that a sufficient number of lifts have been evaluated to enable them to prepare a tentative set of standards and specifications governing the safety function and ease of operation of lift systems. We plan to submit a tentative set of standards and specifications for automotive lifts to the VA Central Office Adaptive Automotive Equipment Committee in September of 1976. After appropriate reviews at several levels and after consultation with manufacturers and other interested agencies, a compliance test program will be initiated for period testing.

SERVO SYSTEMS

In general there are two classes of servo systems for control: (1) 2-degree-of-freedom systems which provide acceleration and braking, and which require steering by conventional equipment. Devices of this type are the Volvo and the CCI-Harden system; and (2) 3-degree-of freedom systems such as the Scott, Sevier, and Lunar Rover whose control systems provide braking, acceleration and steering. The performance characteristics of most of these systems are relatively unknown. Except for the Scott van, we have almost no actual road experience with any of the others. New devices of this type are tested at Texas A&M. A procedure is followed similar to that outlined in Appendix B, describing the evaluation program for the CCI-Harden system. This model will be followed for all the other systems.

SPECIAL SEATING AND MOBILITY SYSTEMS

SEATING SYSTEMS

To fasten the wheelchair to the van several systems employ a device to engage the cross-bar of a conventional wheelchair to clamp it to the floor of the van. This, of course, requires a certain amount of trunk mobility and strength in the arm and hand of the patient. We are quite certain that the conventional wheelchair does not meet the requirements of Federal Motor Vehicle Safety Standards for impact resistance, thus raising the question of the validity of this approach.

The Royce van permits a wheelchair user to transfer from his conventional chair to a specially designed seat which is firmly attached to the wall of the vehicle and which can be rolled forward and locked into place in the driving position. While the special driving seat can be strengthened to meet FMVSS impact resistance requirements, its use requires the ability to transfer from a wheelchair to the driving seat and to pull oneself foward into the driving position. Later one must transfer back to the wheelchair to leave the van. Stowing the wheelchair after transfer is done in various ways.

A third approach to the seating problem embodies the concept used in the Rover Module: essentially, an electric wheelchair designed to meet FMVSS impact resistance requirements. This chair is considered to be a "driving chair," and is kept in the home. He may use another chair for other than driving purposes. When he wants to use the van, he transfers to the automotive Rover Module, which he drives into the van and locks securely in place. The relative merits of all these systems need appraisal.

SPECIAL MOBILITY SYSTEMS

A grey area in the mobility field contains a number of powered vehicles which are neither automobiles nor vans. It is highly questionable if any state will license them as roadworthy vehicles. They are heavier and possess far higher performance characteristics than conventional electric wheelchairs. A number of these have been proposed as intermediate vehicles, somewhere between the wheelchair for indoor use and the adapted sedan or van for handicapped persons. Some resemble modified golf carts; others reinforced wheelchairs.

Included in this class are:

Advanced Wheelchair - three-quarter front view (Figure 18)

Advanced Wheelchair - three-quarter back view (Figure 19)

Chair-E-Yacht - unassembled (Figure 20)

Chair-E-Yacht - assembled (Figure 21)

Para-cycle - unattached (Figure 22)

Para-cycle - attached (Figure 23)

Zip-Car - three-quarter front view (Figure 24)

Zip-Car - three-quarter rear view (Figure 25)

Voyager - without patient (Figure 26)

Voyager - with patient (Figure 27)

Steven Motorized Wheelchair - three-quarter front view (Figure 28)

Steven Motorized Wheelchair - reclined position (Figure 29)

Permobil Exterior - side view (Figure 30)

Permobil Exterior - close-up view showing batteries (Figure 31)

Permobil Superior - close-up view of steering wheels (Figure 32)

Permobil Superior - (Figure 33)

E&J Mark 20 Power Cart - three-quarter front view (Figure 34)

E&J Mark 20 Power Cart - shown with patient (Figure 35)

Indoor/Outdoor Wheelchair - assembled (Figure 36)

Indoor/Outdoor Wheelchair - unassembled (Figure 37)

Obviously a great deal of work needs to be done to arrive at an optimum design of the total van configurations and all the components. This is an arduous and time-consuming task. It can best be done by judicious planning and concerted efforts.

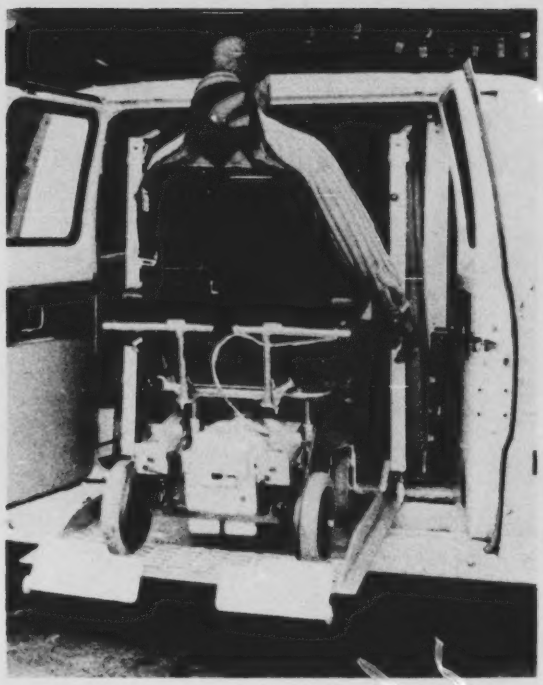


Figure 17. Scott Van - Rear View with Lift.

Figure 18. Advanced Wheelchair - 3/4 Front View.

Figure 19. Advanced Wheelchair - 3/4 Rear View.

Figure 20. Chair-E-Yacht - Unassembled.

Figure 21. Chair-E-Yacht - Assembled.

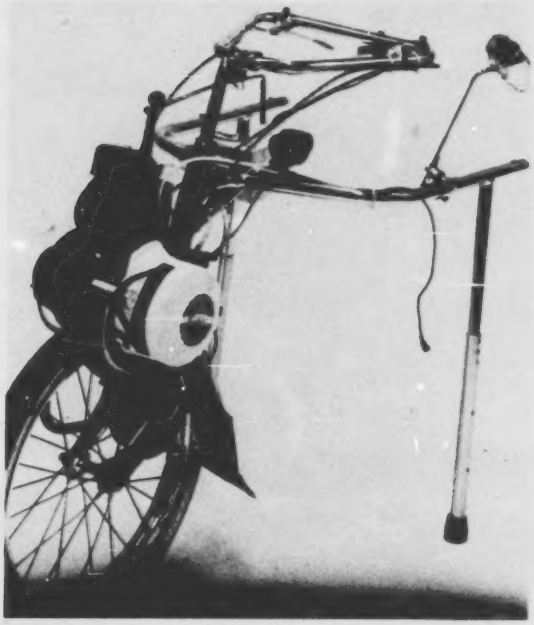


Figure 22. Para-cycle - Unattached.

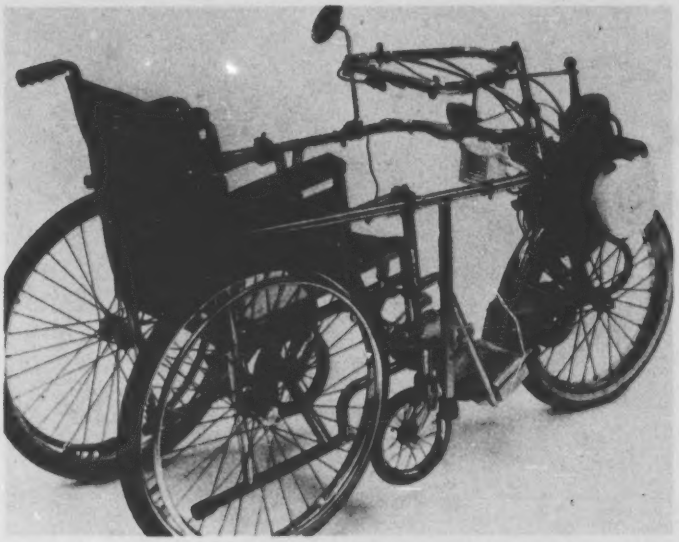


Figure 23. Para-cycle - Attached.

Figure 24. Zip Car - 3/4 Front View.

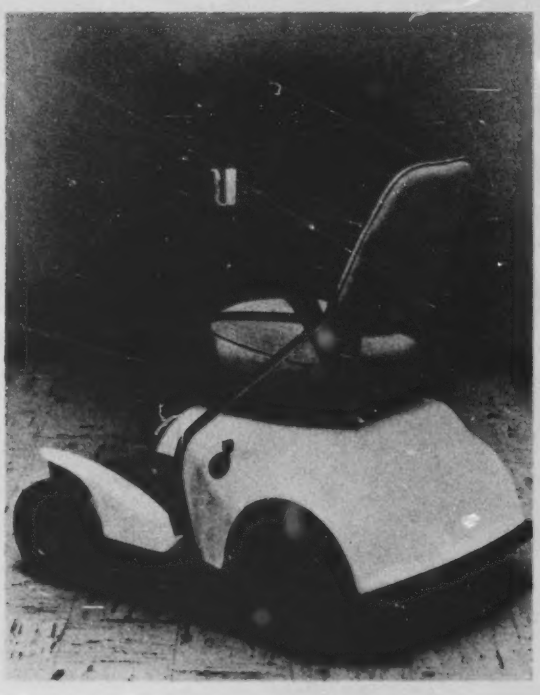


Figure 25. Zip Car - 3/4 Rear View.

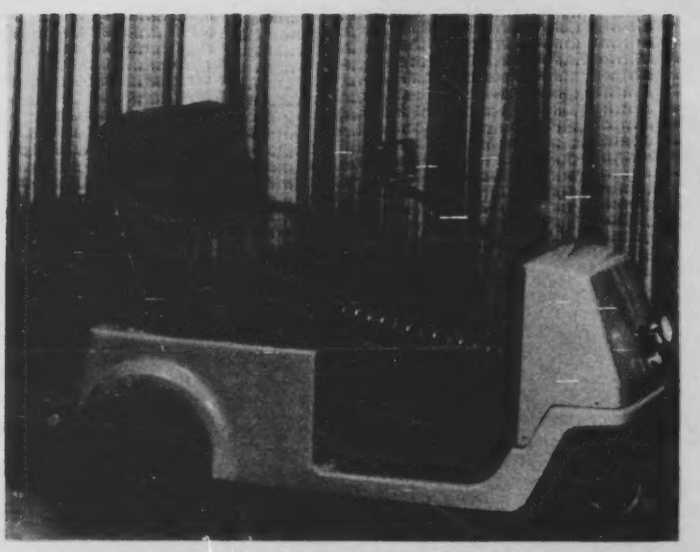


Figure 26. Voyager - Without Patient.

Figure 27. Voyager - With Patient.

Figure 28. Steven Motorized Wheelchair - 3/4 Front View.

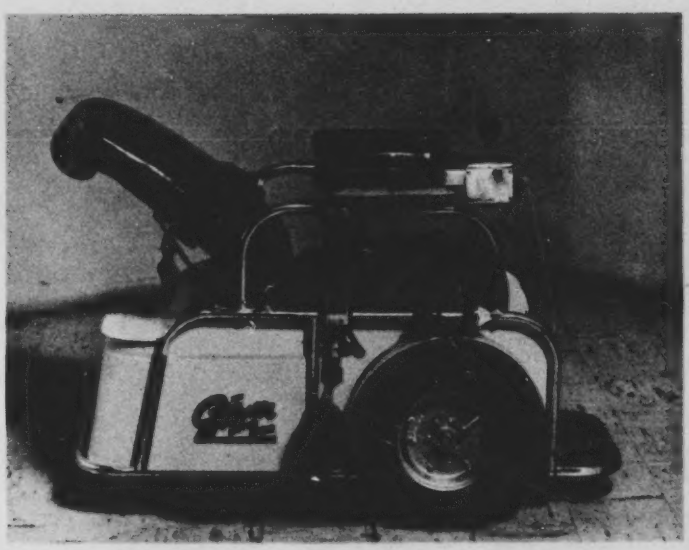


Figure 29. Steven Motorized Wheelchair - Side view, Reclined Position.

Figure 30. Permobil Exterior - Side View.

Figure 31. Permobil Exterior - Close-Up Showing Batteries.

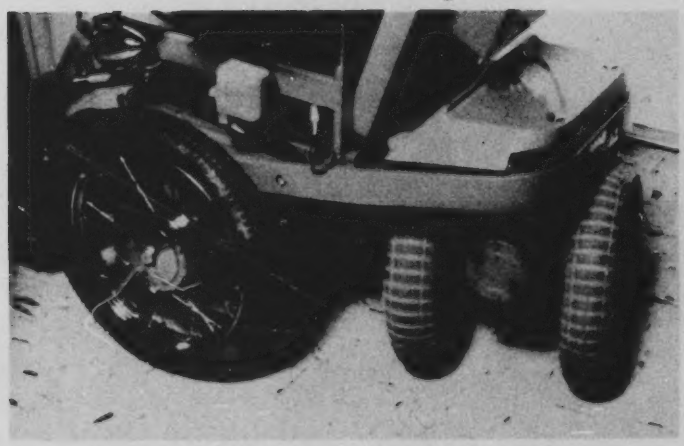


Figure 32. Permobil Exterior - Close-Up View of Steering Wheels.

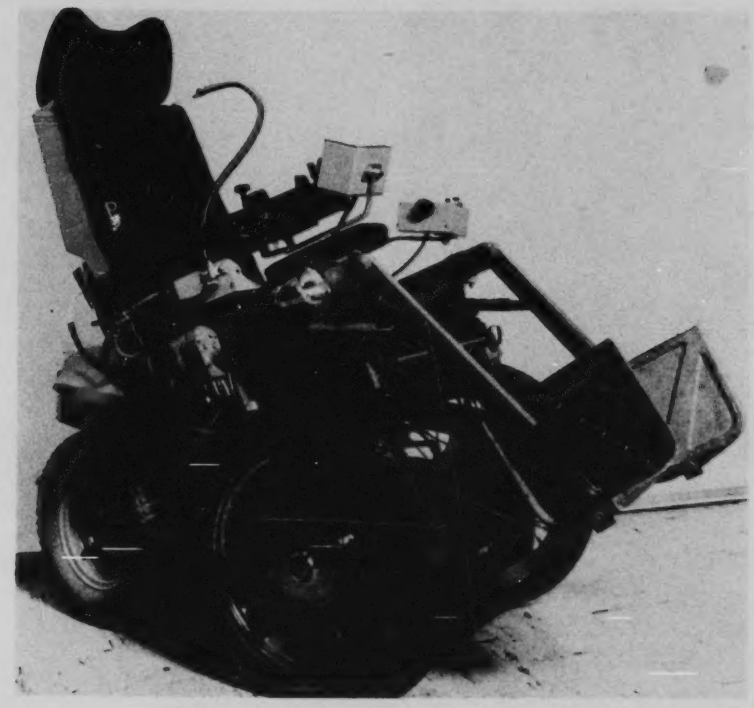


Figure 33. Permobil Superior.

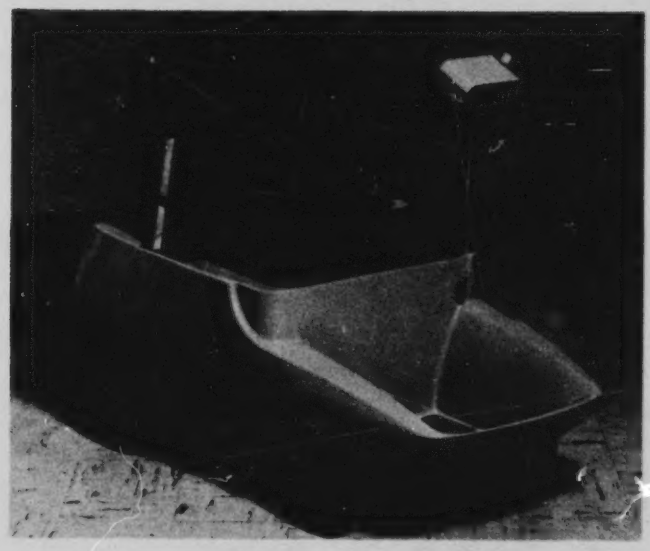


Figure 34. E & J - Mark 20 Power Cart - 3/4 Front View.

Figure 35. E & J-20-Power Cart - With Patient.

Figure 36. Indoor/Outdoor Wheelchair - Assembled.

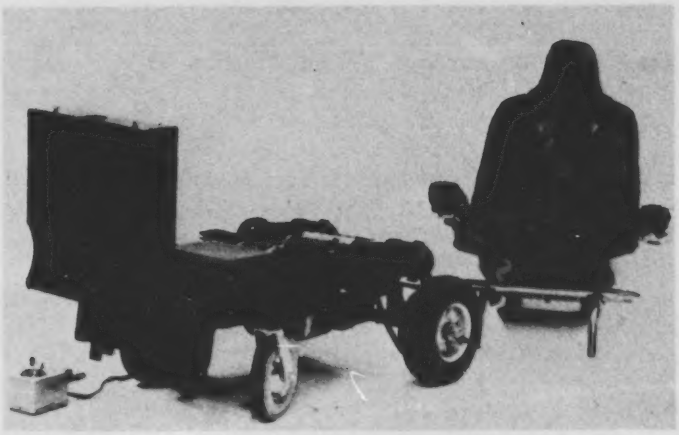


Figure 37. Indoor/Outdoor Wheelchair - Unassembled.

Appendix A

VAPC PROGRAM FOR EVALUATION OF SPECIALLY ADAPTED VANS FOR WHEELCHAIR USERS

A. ASSUMPTIONS

1. Most paraplegic veterans who drive have sufficient upper-extremity strength and range of motion to permit them to operate sedan-type motor vehicles.

   a. The general procedure with individual variations, consists of approaching the automobile on the driver's side in a hand-propelled wheelchair, opening the driver's door, transferring in a lateral and forward direction into the driver's seat or in some cases, into the passenger's seat and then shifting laterally into the driver's seat.

   b. These patients, once positioned in the driver's seat, are capable of reaching out through the open door on either the passenger's side or the driver's side, collapsing the wheelchair by upward movement against the bottom of the seat of the chair, and then pulling the chair into the rear passenger compartment behind the front seat backs.

   c. These patients have no functional <u>need</u> for a van in the sense that they are capable of entering, exiting, and operating standard sedan vehicles with modifications such as hand controls and seat adjustments.

   d. These patients may <u>desire</u> a van for its cargo space, multiple passenger capacity, and/or the current vogue of van use. Vans for these patients require five major modifications:

(1) Removal of the driver's seat; installation of hand controls; an elevator system to permit the patient to enter and exit the vehicle whose floor bed is higher than the conventional sedan; a tie-down system for stabilizing the wheelchair in the operator's position during operation of the vehicle; a redundant control system enabling the patient to open the van doors, and to operate the elevator lift from outside the van and to permit him to store the lift and close the doors from inside the van.

(2) The general mode of operation for these patients is to approach the van from the curb side if it is a side loader or from the rear if it is a rear loader; operate the control system to open the doors; bring the elevator to curb or street level; manually propel the wheelchair into position on the elevator; actuate the elevator ascent control; enter the van by manually propelling the chair off the elevator and into the driver's position; lock the lift in place and close the doors; lock the wheelchair in the driving position.

2. Paraplegic patients with absent or weak upper extremities due to other than primary etiology, and partial quadriplegics whose upper extremity residuals are too limited in strength and range of motion to permit them to operate a manually propelled wheelchair may use electrically-powered wheelchairs. This precludes independent operation of standard sedan-type vehicles since the patient cannot position the chair inside the sedan even though he may be capable of exiting and entering. These

patients have a functional need for one of the two available types of vans:

a. Those whose residual upper-extremity functions enable them to operate an automobile with hand controls may require an otherwise conventional van equipped with hand controls and the previously cited other entry/exit modifications.

b. Those whose residuals do not permit them to operate conventional hand controls may need a specially equipped van (as, for example, the Scott van) which features a special control system enabling the patient to operate the van with one hand with very small forces and very small excursions.

B. PROGRAM

The evaluation is based on the experiences in using vans to train paraplegic and quadriplegic patients to drive in Spinal Cord Injury Centers as required. At the initiation of this study, there are approximately 8 van configurations with sufficient differences among them to warrant comparative analysis of their relative merits. Shown below are the stations and the vans to be assigned to each station. The indicated van mix is designed to obtain comparative analyses on the most significantly different pairs of vans. Analytic depth is achieved by duplicate pairs assigned to several stations. The Motorette/Royce combination occurs more than others (four times) because they are the most widely used and most significantly different systems at the initiation of the study. The Scott van is of a completely different order than the others in that it is not designed for use with conventional hand controls. It features a completely new, unconventional hydraulic steering, accelerating and

braking system. For that reason one Scott van each is being assigned to the largest Centers where sufficient numbers of higher level partial quadriplegics might be expected.

Since the initiation of this program, we have contracted for the services of the Engineering Department of Texas A&M Research Foundation, College Station, Texas, to assist us in evaluating vans and accessories. They perform destructive testing and functional testing. They have an on-site driving range on which instrumented modified vehicles can be driven.

Stations	1st Van	2nd Van
West Roxbury	Motorette*	Royce
East Orange	Drive-Master	Compass
Bronx	Royce	Motorette
Castle Point	Scott*	Drive-Master
Richmond	Helper	Sevier
Tampa	Helper	Speedy Van
Miami	Helper*	Drive-Master
Hines	Braun	Scott
Cleveland	Compass	Speedy Van
Houston	Braun	Compass
Memphis	Sevier	Braun
Long Beach	Scott*	Royce
Wood	Speedy Van	Royce
Texas A&M	Motorette*	Scott Van** Sevier Compass

*Previously ordered.
**The highly unusual design of the Scott Van requires extensive testing at the A&M facility.

Stations	1st Van	2nd Van
St. Louis	Braun	Sevier
Allen Park	Motorette	Drive-Master

1. Purpose. The following outcomes are the objectives of this study:
   a. To obtain field experience on the relative merits of all of the available van systems with particular respect to access systems, driving control, roadability, convenience of various features for individual/family use.
   b. To develop government standards of safety, quality, and durability governing the purchase of vans by veterans under beneficiary entitlements.
   c. Clarification of prescription indications for various types of vans.
   d. To enable qualified veterans to learn to drive, take licensing tests and to give them experience in the use of a variety of van configurations to help them select the most appropriate vehicle for themselves.

C. PROTOCOL

1. Registration. Vans transferred to the stations listed will be registered as U.S. Government vehicles by the station and retained as station property for the purpose of training and licensing selected veterans.

Veterans who are trained and licensed through the use of the government-owned van will not be issued the van but may apply under existing veterans benefits for the type of van on which they were trained or any other vehicle for which they are eligible.

2. Control. Each van assigned to a station will be carried on the CMR of the station's Supply Service which is normally responsible for servicing and maintenance of vehicles.

a. Operational control of the vehicle will be assigned to Chief, PM&R in each station or that Service which maintains a driver training facility. This is essential to avoid unauthorized use and to assure safe utilization by authorized patients under supervision of qualified driver training personnel.

b. The Chief, Spinal Cord Injury Service or his designee will select patients to be trained and licensed on the basis of the prescription indications below.

3. Selection of Patients. Patients to be trained and licensed with these vans are divided into two classes: (a) those selected for purposes of this evaluation, and (b) those to be trained and licensed as part of the general treatment service.

a. For purposes of this evaluation the patient selected should fulfill as many of the following requirements as possible:

(1) legally eligible veterans.

(2) regular or sole use of an electric wheelchair (to establish the need for and the relative merits of the elevator mechanism of these vans).

(3) licensed to drive a vehicle prior to injury.

(4) capable of effectively manipulating standard hand controls or of successfully operating the Scott van trainer.

b. Depending on its availability, the van can also be used in general treatment services to train or retrain any other

patients authorized by the Chief, Spinal Cord Injury Service, or his designee.

4. Training. The training objective in all cases is to obtain a State driver's license for each patient and to meet the local requirements for automobile liability insurance. Due to the unusual design and features of the Scott van, the services of Mr. Scott, the developer, have been engaged to train designated personnel at the Long Beach VA Hospital, Hines VAH, and Castle Point VAH. Mr. Scott will turn the full responsibility for training patients over to VAH staff personnel when he deems them adequately qualified.

5. Evaluation. Monthly reports from each station will be sent to VAPO, N.Y. on forms provided (Appendices A-1 and A-2). Within one month after each patient has received a State driving license his performance in driving and general utilization of the van will be evaluated under the direction of VAPC employing the services of VA and other personnel. After training and licensing, patients may elect to purchase a van or other type vehicle as their eligibility and means permit.

Appendix A-1

VETERANS ADMINISTRATION PROSTHETICS CENTER
252 SEVENTH AVENUE, NEW YORK, N.Y. 10001
CLINICAL DATA RETRIEVAL

FOLLOW UP REPORT-AUTOMOTIVE VAN (VEHICLE)

STATION_____ VAN TYPE_____

CHIEF OF SERVICE_____ MODEL_____
(NAME)

DRIVER TRAINER_____ SERIAL NO._____
(NAME)

DATE_____ MILEAGE_____

1. How long has the van been in service?_____

2. Have all the components (VEHICLE HAND CONTROLS, ETC.) functioned properly since last report? YES ( ) NO ( )

If "NO" describe the nature of the malfunction, and the repairs:

_____

_____

_____

_____

_____

(Name and Address of the company, organization or Hospital Personnel who repaired the van).

NAME_____

ADDRESS_____

_____ _____ _____
CITY STATE ZIP

TELEPHONE NO._____

3. Total time the van was out of service during this reporting period.

_____

4. Have any incidents relating to safety occurred since last report?

YES ( ) NO ( )

(If "YES" specify, relating to (ENTRY, EXIT, TRANSFERRING, VISIBILITY DURING DRIVING, HAND CONTROL, ETC.)

_____

_____

_____

_____

_____

_____
(SIGNATURE OF DRIVER TRAINER)

Appendix A-2(a)

VETERANS ADMINISTRATION PROSTHETICS CENTER
252 SEVENTH AVENUE, NEW YORK, N.Y. 10001
CLINICAL DATA RETRIEVAL

FOLLOW UP REPORT-AUTOMOTIVE VAN (PERFORMANCE)

STATION_____ VAN TYPE_____

DATE_____ MODEL_____

CHIEF OF SERVICE_____ SERIAL NO._____
(NAME)

DRIVER TRAINER_____ MILEAGE_____
(NAME)

A) PATIENT PERFORMANCE

1) Since the last report, how many patients have been trained in the above VAN_____

2) Complete the following on the training of these patients.

PATIENT'S NAME	DISABILITY LEVEL	AGE	HOURS/ TRAINING	TYPE OF WHEELCHAIR USED
1.				
2.				
3.				
4.				
5.				
6.				

3) Special problems in using the van by specific cases listed above:

_____

_____

4) Modifications made to basic van as received:_____

_____

5) How many patients took the State License Tests?_____

_____

6) How many patients were granted a license?_____

_____

7) How many patients bought vans since last report?_____

_____

8) Complete the following on VAN purchases by trained patients

	PATIENT'S NAME	VAN TYPE	VAN MAKE
1.			
2.			
3.			
4.			
5.			
6.			

B) DRIVER TRAINER'S COMMENTS

]) Is this van safe and reliable for teaching? YES ( ) NO ( )

If "NO" explain in relation to entry/exit, hand controls, driving characteristics, visibility, control of accessories, etc.

_____

_____

_____

_____

2) List the advantages of this van:_____

_____

_____

_____

3) List the disadvantages of this van:_____

_____

_____

_____

4) What improvements would you recommend?_____

_____

_____

C) PATIENT'S COMMENTS

_____

_____

_____

_____

_____

_____
(SIGNATURE OF DRIVER TRAINER)

Appendix A-2(b)

VETERANS ADMINISTRATION PROSTHETICS CENTER
252 SEVENTH AVENUE, NEW YORK, N.Y. 10001
CLINICAL DATA RETRIEVAL

PATIENT SCREENING FORM (To Be Used with Appendix)

PATIENT'S NAME_____ DATE_____

AGE_____ HEIGHT_____ WEIGHT_____

DISABILITY (INCLUDING LEVEL OF SENSATION):_____

_____

_____

CAUSE:_____

_____

_____

SERVICE CONNECTED? YES ( ) NO ( )

FORMER LICENSED AUTOMOBILE DRIVER? YES ( ) NO ( )

HOW MANY YEARS LICENSED?_____

WHEELCHAIR

TYPE_____ MAKE_____

COMMENTS:_____

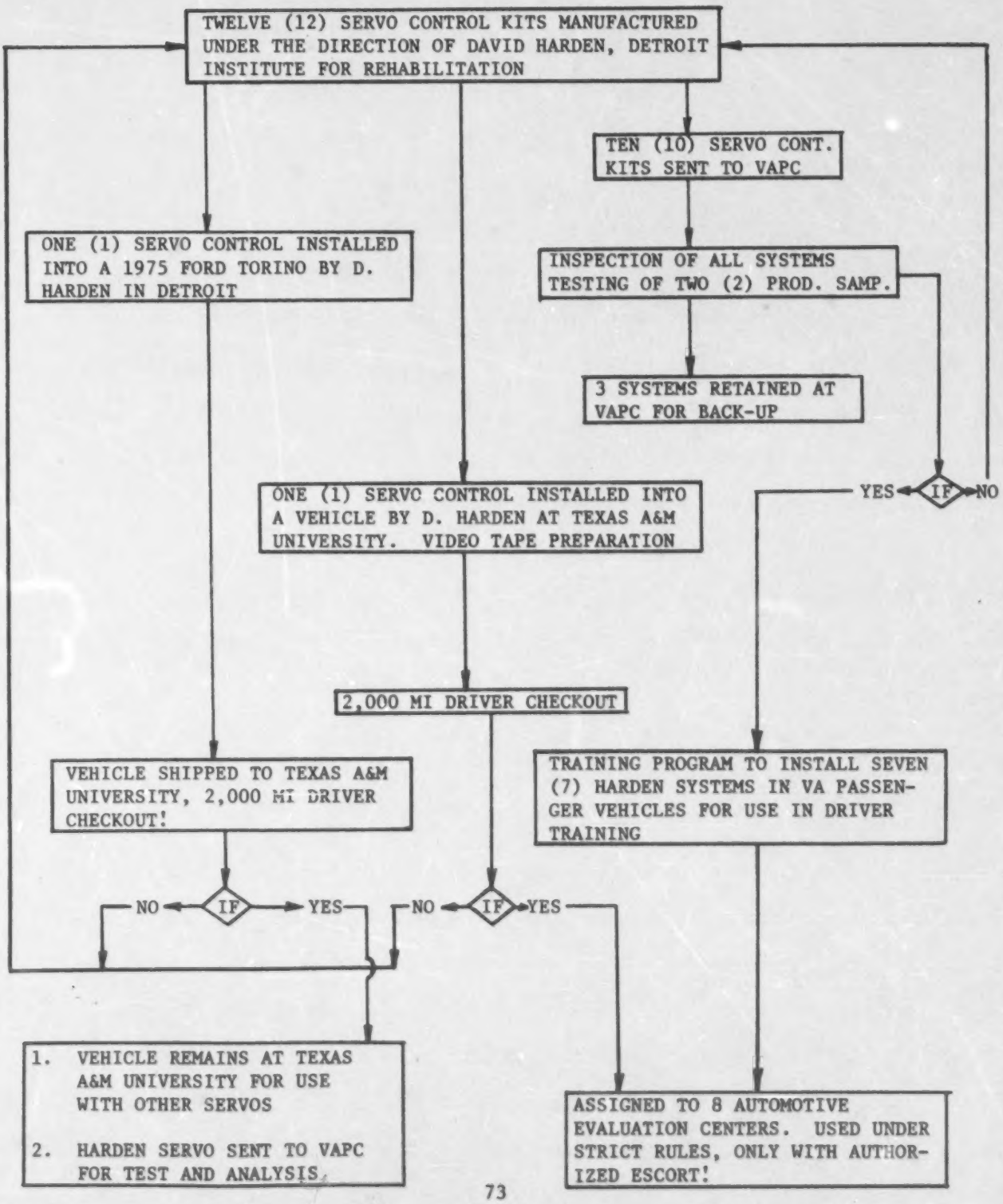
_____

_____

_____
(SIGNATURE OF DRIVER TRAINER)

Appendix B

VAPC PLAN FOR THE EVALUATION OF THE HARDEN AUTOMOTIVE SERVO SYSTEM FOR HANDICAPPED DRIVERS


TWELVE (12) SERVO CONTROL KITS MANUFACTURED UNDER THE DIRECTION OF DAVID HARDEN, DETROIT INSTITUTE FOR REHABILITATION
TEN (10) SERVO CONT. KITS SENT TO VAPC
ONE (1) SERVO CONTROL INSTALLED INTO A 1975 FORD TORINO BY D. HARDEN IN DETROIT
INSPECTION OF ALL SYSTEMS TESTING OF TWO (2) PROD. SAMP.
3 SYSTEMS RETAINED AT VAPC FOR BACK-UP
YES
IF
NO
ONE (1) SERVO CONTROL INSTALLED INTO A VEHICLE BY D. HARDEN AT TEXAS A&M UNIVERSITY. VIDEO TAPE PREPARATION
2,000 MI DRIVER CHECKOUT
VEHICLE SHIPPED TO TEXAS A&M UNIVERSITY, 2,000 MI DRIVER CHECKOUT!
TRAINING PROGRAM TO INSTALL SEVEN (7) HARDEN SYSTEMS IN VA PASSENGER VEHICLES FOR USE IN DRIVER TRAINING
NO
IF
YES
NO
IF
YES
1. VEHICLE REMAINS AT TEXAS A&M UNIVERSITY FOR USE WITH OTHER SERVOS
2. HARDEN SERVO SENT TO VAPC FOR TEST AND ANALYSIS
ASSIGNED TO 8 AUTOMOTIVE EVALUATION CENTERS. USED UNDER STRICT RULES, ONLY WITH AUTHORIZED ESCORT!

VETERAN ADMINISTRATION'S PROGRESS IN AUTOMOTIVE CONTROL SYSTEMS

Anton J. Reichenberger

A variety of assistive automotive control systems is commercially available for use by handicapped drivers in operating standard types of automobiles. The basic requirements state that a motor vehicle must be equipped with an automatic transmission, power brakes, and power steering. All currently known mechanical hand control systems are designed to operate both accelerator and brakes with one hand, leaving the other hand for steering. Left-hand operation of a control system offers maximum driving comfort and is therefore the preferred mode, although most adaptive equipment manufacturers can provide a right-hand operated brake-accelerator control system on request.

We classify all known adaptive hand control systems into three types, push-pull, push-right angle pull, and the push-twist type. To activate the brakes all mechanical hand control systems require a force applied to the control handle in the direction away from the driver and parallel to the steering column. It is recognized that this forward push of the control handle assists the driver in applying the brakes when inertial changes of the motor vehicle occur. To control the accelerator, the three types of control systems differ distinctly by pull, right-angle pull, and twist of the control handle. Specifically, the push-pull system (Figure 1) requires a pull in the direction towards the driver for accelerator control. The accelerator pedal of a push-right angle pull system (Figure 2) is operated by pulling the control handle towards the driver's lap, whereas a twisting motion of the control handle actuates the accelerator pedal of a push-twist system (Figure 3).

Figure 1. Push-Pull Hand Control.

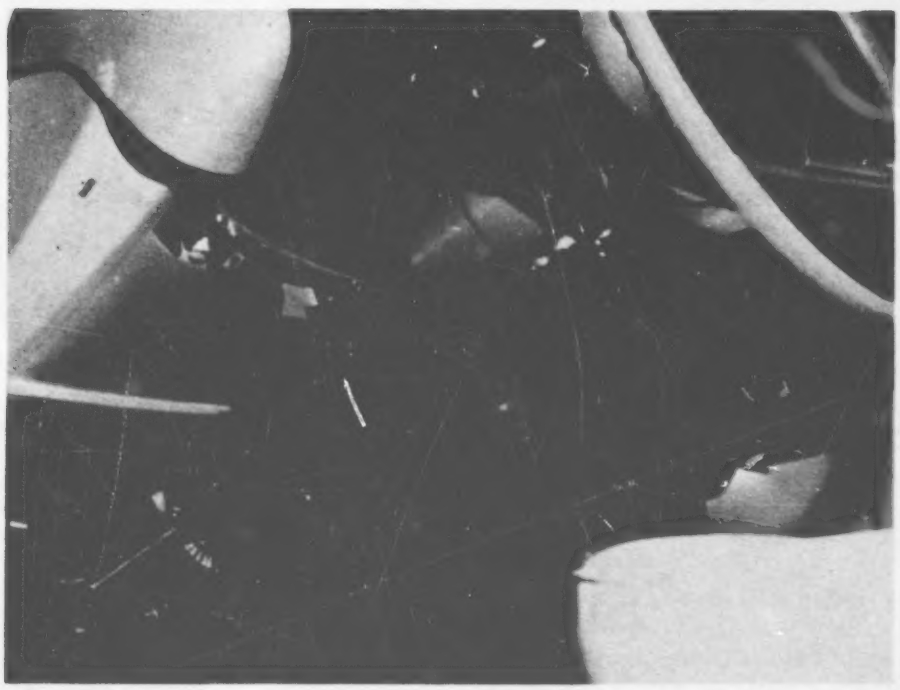


Figure 2. Push-Right Angle Pull Hand Control.

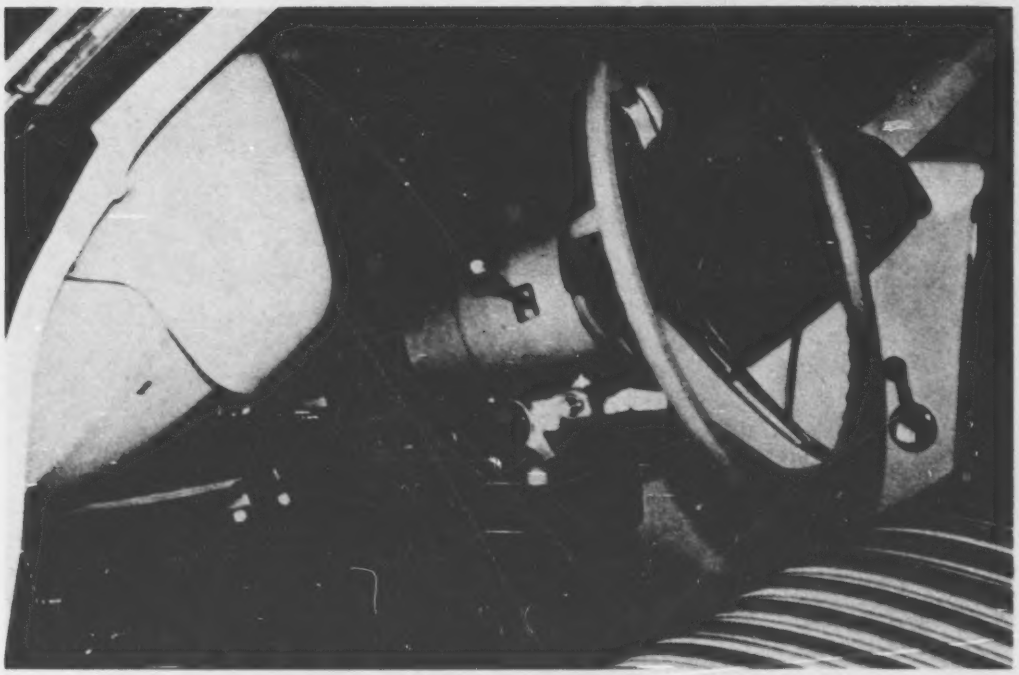


Figure 3. Push-Twist Hand Control

In response to PL 91-666, the VA Prosthetics Center in New York developed standards and specifications for the wide variety of commercially available adaptive automotive control equipment. This document, i.e., VAPC-A-7505-8, defines minimally acceptable levels of safety, quality, and performance. The first compliance tests in accordance with VAPC-A-7505-8 were conducted in the Fall of 1975 and resulted in acceptance of hand control systems from fifteen manufacturers. Of these, nine manufacturers passed all requirements set forth in VAPC-A-7505-8 on the first submission of equipment. The remaining six manufacturers were notified of their shortcomings, and detailed corrective action was suggested in every case. The discrepancies found ranged from reasonable simple problems to potential safety hazards, demanding swift action. A "total

recall" of hand control systems sold by two widely known manufacturers was issued after compliance testing indicated major problems. The cost of equipment replacement involving veteran beneficiaries was fully absorbed by the Veterans Administration.

Although we encountered considerable opposition from many adaptive automotive control manufacturers prior to conducting the first compliance tests during the last year, we are confident that the annual compliance tests scheduled for later this year will be conducted with the full cooperation of the adaptive automotive control industry. Perhaps our objectives to serve the handicapped are better understood a year after the implementation of a workable standard.

There remains a particular concern over the quality of installation of adaptive automotive equipment. Although VA document VAPC-A-7505-8 makes certain recommendations, the integrity of control equipment installations to a wide variety of motor vehicles is not certified either at the time of installation or by subsequent inspections. Improvements are needed in this area to assure that adaptive devices perform for the handicapped driver as well as standard automotive control systems perform for the non-handicapped driver.

Many severely handicapped individuals unable to work with purely mechanical systems could probably be trained to become self-sufficient motor vehicle operators with the aid of power augmented automotive control systems. To this extent, the VA Prosthetics Center is actively involved in the development of a servo operated hand control system for the severely handicapped. An example is the VAPC Double-Wheel Automotive Hand Control System installed to an ADS-71 Aetna Driver Trainer Simulator

for laboratory experimentation (Figures 4 and 5), This electrohydraulic servo system controls motor vehicle brakes and accelerator by displacement of the inner control wheel, The driver applies pressure of one or both thumbs to the rim of the brake-accelerator control wheel to inject a command signal for brake actuation, whereas finger pressure of one or both hands in the reverse direction injects the command signal for acceleration. Both the conventional steering wheel and the brake accelerator control wheel rotate together, making placement of one or both hands in a particular position on the periphery of the double-wheel assembly unimportant.

Another area of great concern is the availability of adequate automotive seating for individuals unable to transfer from their wheelchairs to standard automotive seating after entering a motor vehicle. The structural strength requirements for automotive seating are defined in current Federal Motor Vehicle Safety Standards, and motor vehicle manufacturers must rigidly adhere to provide the public with seating arrangements of acceptable standard quality. This places conventional wheelchair configurations at a notable disadvantage, since wheelchairs have not been designed to withstand the sudden inertial changes often encountered in motor vehicle travel. Fully cognizant of this problem, the VA Prosthetics Center developed an experimental wheelchair tie-down system for use in vans, buses, etc. (Figures 6 and 7). However, we do not believe that any particular wheelchair tie-down system can alleviate the problem, without investigating the structural strength limits of wheelchairs used in motor vehicles. Dynamic testing of wheelchair seating systems in accordance with applicable Federal Motor Vehicle Safety Standards are scheduled to find the answer to this very critical question. We are

Figure 4. VAPC "Double-Wheel" Electro-Hydraulic Servo Control (ADS-71 Car Simulator)

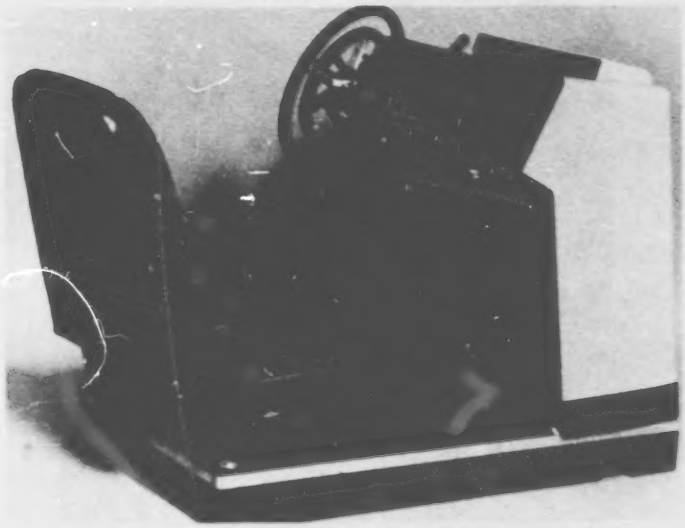


Figure 5. VAPC "Double-Wheel" Electro-Hydraulic Servo Control (ADS-71 Car Simulator

certain that the area of automotive seating for the severely handicapped needs special attention to provide acceptable seating arrangements in the future.

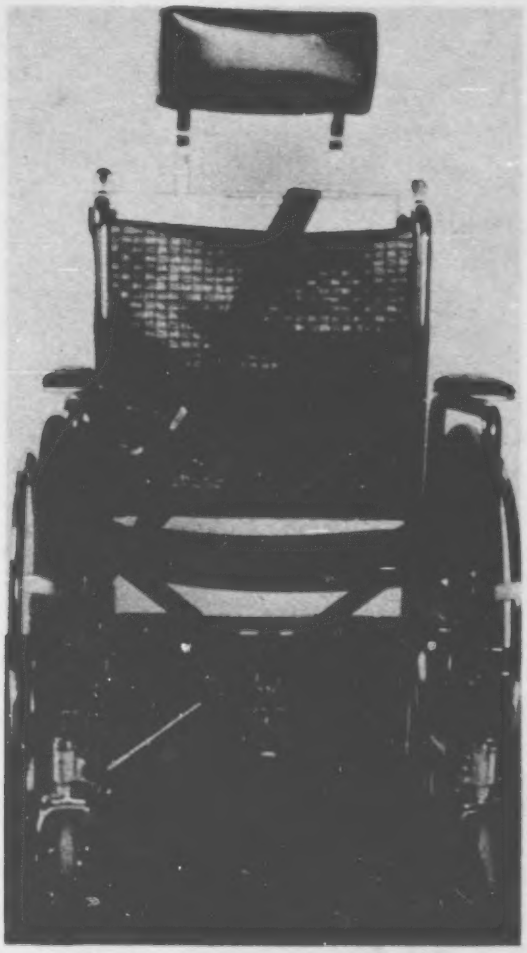


Figure 6. VAPC Wheelchair Tie-Down System, Including Head-Shoulder Constraint (Front View).

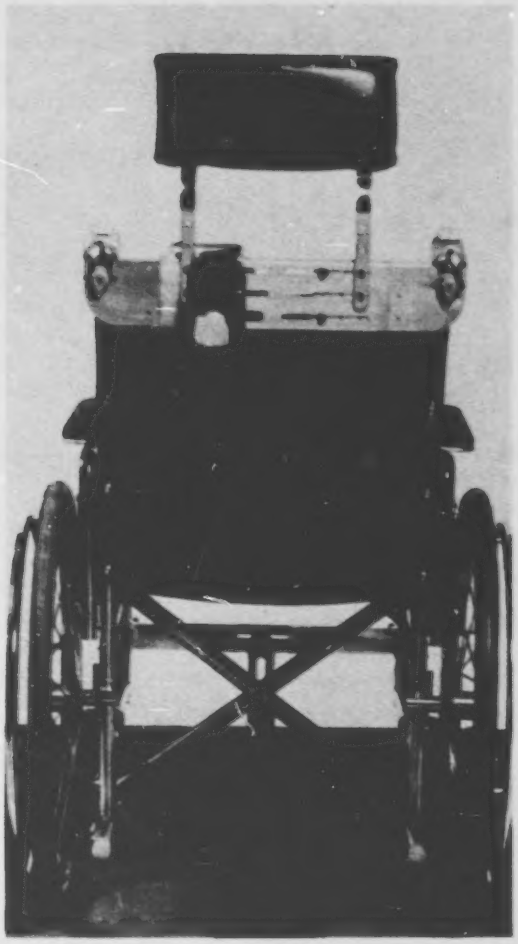


Figure 7. VAPC Wheelchair Tie-Down System, Including Head-Shoulder Constraint (Rear View).

DRIVER EDUCATION AND LICENSING OF THE HANDICAPPED

Harold R. Booher

Driving is one mode of mobility so easily available to most people over the age of 16 in the United States that it is almost assumed to be a right rather than a privilege. For the handicapped individuals, however, obtaining a driver's license or retaining a driver's license after acquiring a handicap is not only far from routine in most states, but may be the critical factor towards initiating and maintaining rehabilitation. The ability to drive can, through enabling the handicapped individual to be employable, satisfying basic social and recreational needs, and providing the opportunity for personal freedom and independence, be a major determinate in making the person with a handicap an asset rather than a burden on society.

While the benefits to the individual and to society through allowing the handicapped to drive are desirable, they can not be done without also considering certain problems. There are major difficulties for example, in providing special driver education and training for all individuals desiring a permit to drive.

There are also large costs, as well as technical, and safety considerations in the provision of special vehicle modifications, adaptive controls, and other special aids for drivers. But the primary question which should be of concern in determining whether or not a handicapped individual should be allowed to drive is how safely that individual can drive in traffic.

The National Highway Traffic Safety Administration has been interested for some years in the problems of driver education, driver

licensing, and driver vehicle interface for the disadvantaged - by which we mean primarily the handicapped and the elderly. Until recently, however, our research has not directly addressed their special requirements. Our position has been - that until we can establish what the driving requirements are and what the driver education goals should be for the normal driving population - it is difficult to specify what deviations or changes are necessary for special populations.

But, even so, some of our past R & D was broad enough in at least two projects so that it has provided products applicable to the disadvantaged population. The vision research done for driver licensing has covered people who could be considered low vision drivers, and also our program to develop dissemination techniques for driver knowledge - primarily driver manuals and some audio-visual equipment for use in State DMV's - is quite applicable to some areas of concern with the disadvantaged. The driver manuals project considered low reading skills of several special populations such as the mentally retarded, the school drop-out, the deaf, and if we are to believe recent findings on the reading levels of the nation as a whole, a large portion (perhaps 20%) of our high school graduates who are otherwise considered normal. A special supplement for drivers over 55 is of interest as well, since it was found that of all the groups studied, this was the only group who had special driving knowledge needs that didn't apply to the other groups.

Last year, however, our emphasis on R & D directed toward the disadvantaged has increased greatly.

Discussions with Dr. Max Muller of the Bureau of Education for the Handicapped and Dr. John Eberhard of my office and very capable

special driver educators like E'lise Brown, who is chairing one of the panels this week, led us to initiate a project sponsored jointly by the Bureau of Education for the Handicapped which would provide an assessment of just what is the impact on driving by special populations. In addition to assessing the state-of-the-art, we are looking to this study to see if there is any kind of general research model worth developing with respect to education and licensing the handicapped - and what new research should be initiated for specific target populations such as the mentally retarded, those with hearing or musculoskeletal handicaps, those with epilepsy or cardiovascular diseases or any other group who could be considered in a special class of the disabled.

In addition, there are two new projects just being initiated this year. One is directly applicable to the work being considered here this week - titled Assessment of Vehicle Safety Problems for Special Driving Populations. The purpose of this project is through an interview questionnaire to analyze the handicapped and elderly safety problems (including problems with adaptive controls) associated with near accidents.

The other is a two-year project to develop and validate performance skill testing procedures for the older driver. It also is planned that this project will specify areas where older drivers can exercise certain compensatory actions or undertake special training to improve known deficiencies. This project also intends to develop a driver license administrator guide book for implementing an aged driver license and improvement system. More specific details on these two projects might be appropriate for the actual workshop discussions.

I would now like to introduce Mr. Paul Brainin of Dunlap and Associates, who will talk about the specific objectives, particular difficulties, and general findings in the study now being carried out by his company for the NHTSA/ODPR. The results of this study should hopefully set the stage for future R & D priorities in driver education and licensing for the handicapped.

THE STATE OF THE ART OF DRIVER PERFORMANCE

Paul A. Brainin

The purpose of my presentation is to provide a broad based background for the panel discussions. The presentation will very briefly provide an overall picture of the state-of-the-art of research concerning the driver who has a medical condition that could affect his driving ability. In a sense, my speech, since it gives an overall view, is beyond the specific boundaries of the workshop. My speech contains descriptions of medical conditions, as they relate to driving, that are not subject specifically to panel discussions. The information is intended to help place the workshop in the proper context of the much broader problems of all of the driving disabled.

As a member of the Steering Committee, I have been assured that there will be future workshops that will focus on other handicapped drivers. This workshop is only the first in a series of workshops. Hopefully, my presentation will help emphasize the need for these additional important discussions. Certainly, there are many, many more individuals who have disabilities other than those whose handicaps we will be discussing.

I will open my presentation with a brief description of the driving task, and I will explain that, although a start has been made to define the components of the activities of driving, the most critical details of the perceptual, cognitive, and motor aspects have not been delineated. This has not been accomplished for either the able-bodied or the handicapped driver. I will try to describe the difficulties of

interpretation of the data on drivers with medical conditions. There are many philosophical, methodological, and scientific problems that make the discerning of trends in the literature formidable.

The major focus of my presentation concerns the research studies of the driving performance of handicapped people. I will also discuss the information I have collected about driving assessment. This is assessment of handicapped individuals for selection into a driver training program as well as assessment used as a diagnostic tool in deciding how to proceed in training. Assessment is also discussed in terms of evaluation during training programs and in terms of evaluation of the success of completed programs. In addition, I will attempt to relate the prominent points of driver education, as they appear in the relevant literature. I will spend a very little time on the impact of therapeutic drugs on driving, commercial driving, and the legal and licensing aspects of private and commercial driving.

It is hard to do justice to the state-of-the-art in my brief presentation. The issues are complex and confusing, and they do not lend themselves to straightforward and simplified explanations. This is true whether the presentation is spoken or written. In this vein, I have decided that, for those who are interested, a more faithful rendition of the state-of-the-art is needed. Since this is quite lengthy and not totally appropriate in this presentation, I refer the reader to a report that will be available shortly. Dunlap and Associates, Inc., and myself, as Project Director, are under contract to both the U.S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA) and to the U.S. Department of Health, Education, and Welfare, the Bureau

of Education for the Handicapped (BEH). This contract entitled "Impact on Driving by Special Populations" (Contract No. DOT-HS-5-01206) requires a final report that will cover, in detail, the topics I referred to above and, shortly, in my brief presentation. This report should be available by the end of the year from NHTSA or BEH. Requests for the report can be made directly to NHTSA or BEH in Washington or through me, c/o Dunlap and Associates, Inc., One Parkland Drive, Darien, Connecticut 06820.

DRIVING PERFORMANCE BY THE HANDICAPPED: VISION AND AUDITION

Harold R. Booher

The Office of Driver and Pedestrian Research in the National Highway Traffic Safety Administration has stressed research and development projects for two major purposes: First, those designed to provide data which tell us how well the handicapped driver performs normal driving tasks with whatever adaptive controls or aids that are at his (or her) disposal; and second, those designed to develop education and licensing programs which can improve driving performance in those areas where driving skills may be not only weak but also critical to safe driving performance.

Two areas of considerable interest in licensing the disabled to drive has been those of the low vision and hearing impaired drivers. This paper is based on the results of several in-depth surveys and analyses of past research relating to driver education and training needs, driver licensing requirements, and actual driving performance of both individuals with low vision and those with hearing deficiencies.

This afternoon I would like to present briefly what we have found the state-of-the-art to be regarding five factors and their relationship to visual or hearing handicaps. The first of these factors, the importance of the function to driving, is not easily answered for audition because studies have not been able to clearly show that hearing is necessary for most driving tasks. The importance of the visual sense cannot be stressed enough, however. While the kinesthetic, vestibular, and auditory senses play useful parts, it is generally estimated that the

information channeled through the eyes accounts for more than 90 percent of the total information the driver uses in performing most driving tasks.

I also plan to cover briefly the accident statistics relating to the low vision and deaf drivers, conventional mechanical aids available for these specific handicaps, and the current status of education and training programs specifically designed for improving the driving skills of these two areas, as well as a summary of State Department of Motor Vehicles standards for licensing persons with deficiencies in these two major senses.

It would appear that the tremendous dependence on the visual system would preclude any question regarding driving by the visually handicapped from the standpoint of driving with any degree of safety. Many low-vision individuals have been licensed to drive, however, and except for the totally blind who probably account for less than 7 percent of the severely visually impaired (Riley, 1969), there is little research data to support restrictions on driving based solely on visual limitations as conventionally measured.

Through the use of telescopic spectacles and similar low vision aids, individuals with poor vision (well over 20/200, Snellen in some cases) are able to pass the static central acuity tests for driver licensing in some states. One practitioner alone (Finebloom, in Hayes, 1975) has rehabilitated over 300 patients through the use of a bioptic telescope sufficiently well enough to operate a motor vehicle and pass a driver's license examination. The bioptic telescopic spectacles (Figure 1) consist of two miniature Galilean telescopes located one each in the upper portion

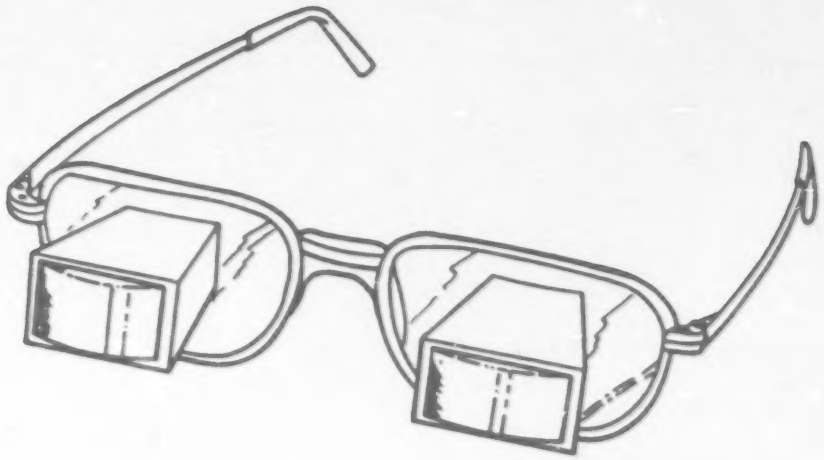


Figure 1. Bioptic Telescope.

of each carrier lens having the patient's normal refractive correction. When using the spectacles for driving, the driver lifts the head to look through the carrier lens for general viewing. A head lowering action is required to bring the telescope into focus for reading signs and spotting other objects in the driving environment.

Although the individuals using bioptic telescopes for driving would be unable to pass the standard visual acuity tests given in the states without the aid of the telescopic lens, the major question in licensing the driver requiring a low vision aid is whether he or she can drive without posing an undue safety hazard to themselves or to others. Proponents of licensing the low vision driver cite case studies to show

the excellent driving records of drivers with vision aids (Finebloom in Hayes, 1975; Levin and Kelleher, 1975; Korb, 1970).

Those opposed to licensing the use of telescopic devices cite potential highway safety hazards which reasonably could result from reduced central fields, the presence of a ring scotoma, caused by the juncture of the telescope with the carrier lens, and illusory displacement of images with head movements (Keeney, Weiss, and Silva, 1974; Fonda, 1974). Only one study on the visually handicapped provides data collected from official accident records, however (Korb and Riley, 1973). That study was based on the driving records of 128 low vision drivers in the state of Massachusetts. Although they do not report information about the number of miles driven by the bioptic lens wearers, their results revealed that the visually handicapped drivers have a record of only one accident in 341 man-years as opposed to one accident for every 17.7 man-years of driving by the general population.

One of the problems in restricting driving by vision deficient individuals has been the lack of a definition of the visual requirements for safe driving. Static visual acuity with or without a telescopic aid is only one of several visual functions that has been identified as important to driving (Henderson and Burg, 1974). The visual functions considered in the literature as potentially important to driving with major driving problems which could result from deficiencies in the specific function are summarized in Table 1. These are not all equal in importance to driving safety. For example, a deficiency in accommodation may cause a relatively minor safety problem in being able to focus on dashboard instruments, while deficiencies in angular movement detection suggest potential safety problems in most of the critical driving tasks.

Table 1.

Visual Functions	Potential Driving Problems
Accommodation Amplitude	• Inability to clearly focus eyes on dashboard instruments
Accommodation Facility (Speed)	• Long time delay in changing focus between road and instrument panel
Adaptation	• Entering tunnels in daylight
	• Headlamps and roadside lighting disturbing dark adaptation
	• Slow dark adaptation at twilight

Table 1. (Continued)

Visual Functions	Potential Driving Problems
Angular Movement	• Degradation in tracking behavior in steering
	• Reduced ability to notice other moving vehicles or pedestrians on collision course
	• Increased intersection dangers
Color Vision	• Confusion with red/green/amber traffic lights
	• Insensitivity to red lights
Dynamic Visual Acuity	• Degradation in resolving detail of obstacles, moving vehicles, pedestrians
Field of Fixation	• Diplopia under conditions of poor visability
Fixations	• Eye movement deficiencies in tracking objects

Table 1. (Continued)

Visual Functions	Potential Driving Problems
Fusion	• Possible diplopia under conditions of reduced visability
Glare Sensitivity	• Slow recovery time from glare sources • Special problem with beginning cataracts
Movement in Depth	• Poor ability to detect slowing or stopped vehicles in path of driver
Phorias	• Possible diplopia under conditions of low visability

Table 1. (Continued)

Visual Functions	Potential Driving Problems
Static Visual Acuity	• Inability to read road signs • Inability to correctly identify objects, particularly at twilight or night
Stereopsis	• Problem of judging distances of vehicles
Vergences	• Difficulties in saccadic and pursuit fixations or in changing focus between near and far objects
Visual Field	• Difficulty in detecting, identifying and interpreting motion and form information in the periphery while maintaining general orientation and vehicle guidance

CURRENT STATE PRACTICES

At present, all 50 states (and the District of Columbia) are in complete agreement that vision is important to driving safety. All use some vision test in their licensing program, which is not necessarily the situation in Europe and other countries of the world. However, there is considerable disagreement as to what tests to use, what minimum standards to enforce, and whether to re-test vision each time the license is renewed. This lack of standardization is shown in Table 2. All states

Table 2. Summary of the Number of States Using Various Vision Tests in Their Licensing Program

	USE	
TYPE OF TEST	INITIAL LICENSE	LICENSE RENEWAL
STATIC ACUITY	51	31
COLOR VISION	42	27
DEPTH PERCEPTION	31	18
VISUAL FIELDS	20	9

measure static visual acuity before issuing a driver his initial license. However, only 31 states routinely re-test the driver's acuity when he renews his license each two to five years thereafter. Although 42 states test color vision for the initial license, only 27 re-test; 31 states initially test depth perception but only 18 re-test; and 20 states initially measure visual fields but only 9 re-test. From a literature review and a task analysis of visual requirements for driving, Henderson

and Burg concluded that several of the visual parameters not particularly important to safe driving (e.g., color and stereopsis) are being unnecessarily measured by some states while many that appear most important to driving (e.g., angular movement, dynamic visual acuity, central movement in depth) are not measured by any states.

Table 3 shows the variations among states in the minimum level of acuity that is acceptable for licensing. Although 20/40 Snellen acuity is the most common, minimum requirements range from 20/20 to 20/70 depending upon whether the applicant normally wears glasses and/or is blind in one eye.

Table 3. Summary of Static Acuity Screening Standards Used in State Driver Licensing Programs

MINIMUM SCORE (SNELLEN FRACTION)	TEST CONDITION			
	WITHOUT GLASSES		WITH GLASSES	
	TWO EYES	BLIND ONE EYE	TWO EYES	BLIND ONE EYE
20/20		1		
20/25		1		
20/29		1		
20/30		13	1	8
20/33		1		
20/40	48	33	38	36
20/45	1			1
20/50	1	1	4	2
20/60			2	2
20/70	1		6	2

Next to static acuity, visual fields have received the most interest from vision care specialists in recommending requirements for

safe driving performance. Licensing requirements of states presently range from 90 degrees to 140 degrees field extent (Table 4). This lack of standardization is in some part due to the fact that there is considerable differences of opinion among experts about the way visual peripheral fields are actually used in driving. Many investigators assume that peripheral vision is used primarily to detect objects and events, but the head and eye continuously move the area of foveal vision for more close examination (Mourant, Rockwell, and Rackoff, 1969). At least one investigator (Richards, 1967), maintains that fields as small as 50 degrees can be acceptable if the person learns to compensate through the use of mirrors and increased head and eye movement. Allen (1969) however, argues that the bulk of driving information must come directly by peripheral vision because of the relatively long time required to acquire central fixations in assessing the entire driving scene and still be able to maintain orientation and vehicle guidance. It is his recommendation therefore that visual fields should be no less than 70 degrees right and 70 degrees left.

Table 4. Summary of Visual Field Screening Standards Used in State Driver Licensing Programs

MINIMUM FIELD	NUMBER OF STATES
100°	4
110°	1
120°	4
130°	1
140°	5
NOT STATED	5

Good driving performance in general requires adequate peripheral vision (Mourant and Rockwell, 1972), but a recent study conducted by University of North Carolina (Council and Allen, 1974) with 52,000 North Carolina drivers was not able to show significant differences in accident involvement between those with narrow visual fields (140 degrees or less) and those with wide visual fields (more then 160 degrees). Henderson and Burg (1974) point out that while visual fields are important for useful peripheral vision in detecting motions and interpreting peripheral information for potential dangers, the static perimetry measures conventionally used by vision specialists do not adequately reflect these dynamic visual functions.

The one dynamic visual parameter which has been studied in some detail, dynamic visual acuity (DVA), has been shown to correlate high with driving performance (i.e., higher accident frequency and rate with poorer DVA). Burg (1967, 1968) reported results of a large-scale investigation on almost 18,000 California drivers in which DVA had a strong and consistent relationship with driving record. More recently Shinar, Mayer, and Treat (1975) found DVA to be the single best test for discriminating between accident-at-fault drivers and no-accident drivers.

The Henderson-Burg study (1974) done for the National Highway Traffic Safety Administration (NHTSA) with 669 licensed California drivers is to date the most thorough study on the subject and does show a positive relationship between accident overinvolvement and poor visual ability. One type of analysis used by Henderson and Burg is illustrated in Figure 2. For these results, the accident rate for those individuals scoring in the top ten percent on each test was compared with the

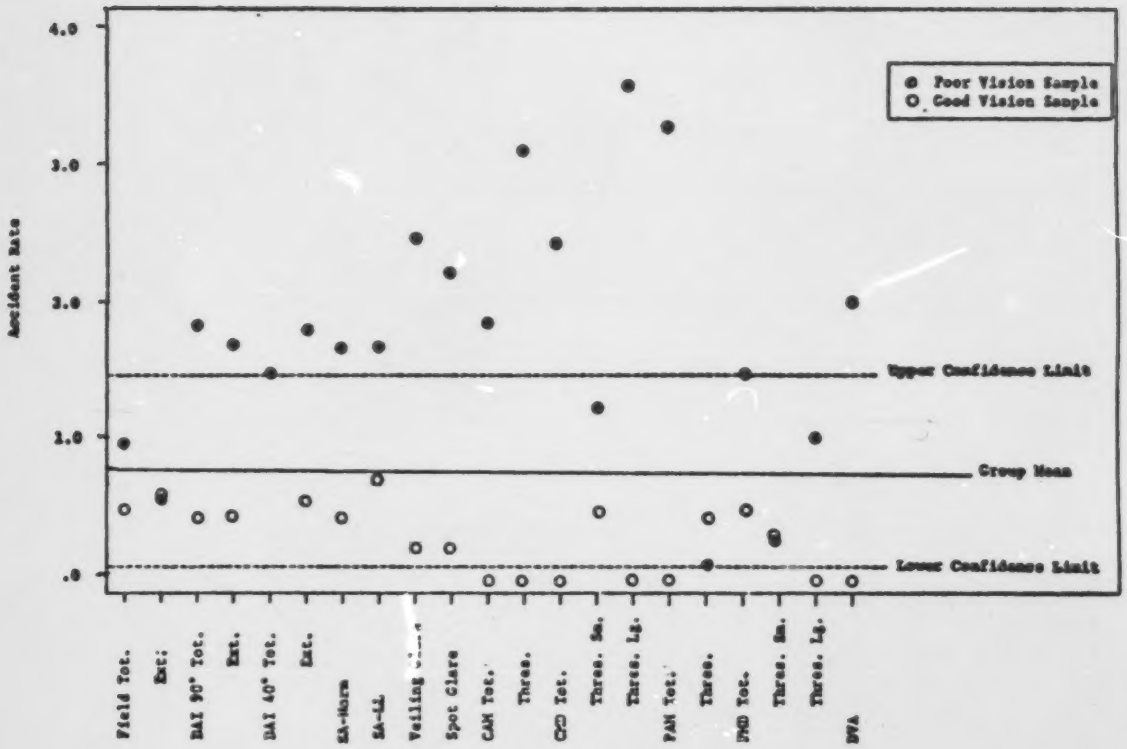


Figure 2. Mean Accident Rate for Poor Performers and Good Performers Aged 50 and over on Henderson-Burg Vision Tests.

accident rate for those scoring in the bottom ten percent. The color band in the center represents the limits within which the mean accident rates for these sub-samples would fall on the basis of chance alone. Clearly, poor performers on most tests had mean accident rates above chance limits; good performers on many tests had mean accident rates below chance limits. The results also indicate that the less conventional tests such as peripheral angular movement and central movement in depth are stronger indicators of accident rate than the conventional static measures of visual fields and visual acuity.

REHABILITATION OF LOW VISION DRIVERS

An important factor in safe driving performance of low vision individuals is the selection process imposed on them in obtaining a drivers license. Of the patients who can be rehabilitated with a bioptic for static viewing very few can use it in combination with performing a complex task like driving.

Some of the prerequisites considered by Kelleher and other vision care specialists (Hayes, 1975) in deciding whether the low vision patient should attempt to drive with a bioptic telescope are:

1. head and neck mobility in conjunction with eye mobility,
2. full visual fields at least 110 degrees with no large scotomas,
3. stable visual condition of long duration,
4. normal color perception,
5. normal eye mobility,
6. adequate central visual acuity to meet minimum state licensing,
7. sense of high moral responsibility, and
8. intelligence and motivation.

Future rehabilitation of low vision drivers may be necessary for vision deficiencies other than that which can be corrected by any type of refractive lenses, however, whether or not bioptic telescopes are involved. People may be handicapped for night vision, eye movements, or for movement detection while still possessing adequate static visual acuity and static visual fields. Research efforts are only just being started by vision researchers and clinical optometrists to study the

effectiveness of perceptual training and development of compensatory activities for vision deficiencies.

AUDITION

The importance of audition to driving is far less than that of vision, but the person with a hearing handicap also faces difficulties which require special consideration for safe driving performance. Some problems like not being able to hear a car start while turning the ignition key are more of an inconvenience than a safety problem, but the inability to hear sirens, horns, sounds of other vehicles, or trying to communicate to other passengers while driving could reasonably pose serious traffic safety hazards. The problems of learning safe driving information and passing the written license examinations are largely because of the general low reading level of the deaf. A problem which may become greater in the next few years is that of commercial vehicle operators. The discrimination against the hearing handicapped in operating commercial vehicles is much greater than for private vehicles, but there is really no solid research basis at this time to support the more rigid standards.

DRIVING PERFORMANCE OF THE HEARING IMPAIRED

Opinion is usually positive on the safe driving ability of the deaf driver (Mirkin, 1967; Fox, 1969; Finesilver, 1970; Misner, 1975), although Cheetham (1974) feels that at least in South Africa the deaf are likely to be involved in an accident with serious consequences. Finesilver in noting that deaf drivers have fewer violations and fewer offenses than hearing drivers, suggests that since the deaf drivers have fewer auditory distractions, they may have an increased ability to concentrate on driving which makes them better drivers.

The results of controlled surveys and studies, however, are not so conclusive. Factors such as age, driving exposure, occupation, sex, and type of vehicle driven when considered seem to be important to the determination of how safe is the driving performance of the hearing impaired.

When the records of hearing deficient drivers are compared with average drivers' records, the hearing deficient driver tends to show a better than average driving record (Shein, 1968; Washington, D.C., DMV, 1973). A well known exception to this is a study done by Coppin and Peck (1973) for the California State Department of Motor Vehicles which reported that a sample of deaf drivers had 1.78 times as many accidents and 1.26 times as many convictions as did the non-deaf. In that study, however, the deaf differed from the non-deaf on a number of other variables, e.g., mileage driven, occupation, and sex. A second study by Coppin and Peck (1964) matched two large samples of deaf and non-deaf on a number of variables including age, annual mileage, occupation, sex, and area of residence. This time it was found as shown here that deaf females did not differ significantly from non-deaf females on either accidents or violation points (Figure 3). The deaf male, however, had an accident rate 1.8 times higher than that of the non-deaf male.

Age may also be an interactive factor. Roydhouse (1967) describes a survey using self-report accident data from 220 deaf drivers in New Zealand. The analysis of that data showed drivers under 50 years of age had a lower accident rate than the national average but drivers over 50 years old had a higher accident rate.

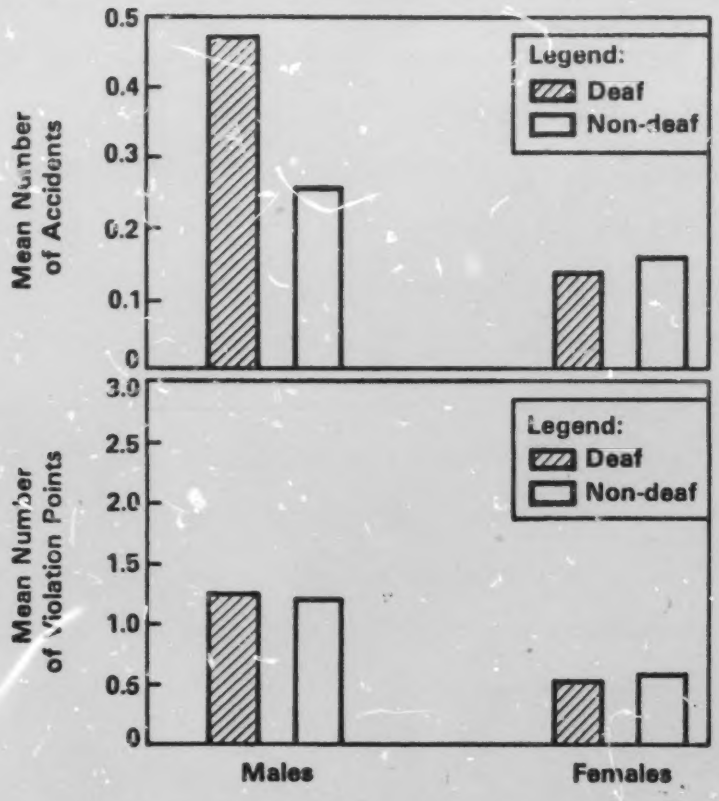


Figure 3. Mean Number of Accidents and Violation Points of Deaf and Non-deaf Drivers by Sex (Three Year Record) (Coppin and Peck, 1964).

Auditory Requirements

As far as the specific auditory requirements necessary for safe driving performance, very little is known. No auditory requirements have been found through driving task analysis to be directly related to behind-the-wheel performance for truck and bus driving (Henderson and Burg, 1973), and only one critical task - listening for train whistles at highway-rail grade crossings - was found to have unique auditory requirements for safe driving of a private automobile (Henderson and Burg, 1974).

Engine noise may be an important auditory area for safe driving performance. Truck drivers, for example, should be able to hear above the noise of the engine, particularly when they are maneuvering their vehicles in congested city traffic and in suburban areas where there may be children playing. This contention is supported by the results of a recent simulator experimental study where the deletion of a velocity-dependent auditory cue simulating engine noise appeared to contribute to deterioration in safe driving responses (McLane and Wierwille, 1975).

At higher speeds, however, where the hearing of a horn or siren would be most important in accident avoidance, it is doubtful that any level of hearing is particularly useful. The results by Henderson and Burg (1974) on investigation of the audibility of horns and sirens in automobiles with windows open and with them closed concluded from data such as shown in Figure 4 that the ambient noise level inside passenger cars moving at speeds 30 to 60 mph provides a level of masking equivalent to a very severe hearing loss. The top line in Figure 4 represents the noise level, the bottom two are horn db levels. Note that the horn sound never gets loud enough to be heard above the noise. Because of this masking noise, the sounds generated by automobile horns and emergency vehicle sirens have little warning value under many conditions regardless of the auditory capability of the driver. The masking is not present, however, when the driver is stopped or when the warning signal comes from a vehicle bound in the same direction as the drivers own vehicle.

It is generally accepted that the deaf or hard of hearing can compensate for their handicap by increased visual vigilance sufficiently

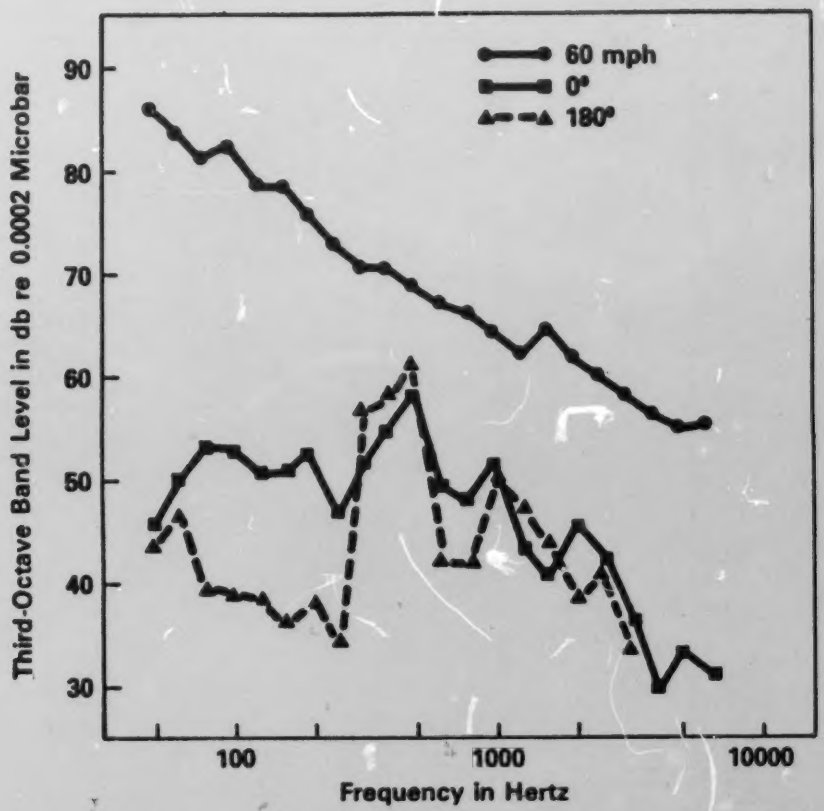


Figure 4. Horn Audibility Inside an Oldsmobile Traveling 60 mph with the Driver's Window Open for Aspect Angles of 0° and 180° (Henderson and B[illegible], 1974).

well to drive private vehicles or light commercial transport. Generally special mirrors are the only special requirements. This is not true with commercial vehicles however.

Considerable variability exists in medical guidelines for licensing the hearing impaired to drive, both in defining criteria for what constitutes a severe hearing loss and the restrictions placed on the "Hard of Hearing" driver (Table 5).

DRIVER EDUCATION AND SPECIAL AIDS FOR THE HEARING IMPAIRED

The greatest problem in driver education for the hearing impaired is, as in all education of the deaf, the difficulty of verbal

Table 5. Medical Guidelines for Licensing the Hearing Impaired to Drive Private and Commercial Vehicles

Source	Hearing Loss Characteristics	Restrictions
Private Vehicle		
USDHEW Public Health Service (1969)	"Hard of Hearing" on voice recognition test.	
	• Hard of hearing from before age 15 or if after 15, aware of deficiency more than 4 years	• Two side mirrors in addition to inside rear view mirror
	• Over 15 and aware of deficiency less than 4 years	• Two side mirrors plus successful completion of special deaf driver course
Quebec Department of Transport (1973)	Deaf in one or both ears	• Side mirror on side(s) of vehicle corresponding to side(s) of hearing loss
Canadian Medical Association (1974)	Significant hearing loss in one or both ears	• No restrictions
Waller, 1973	Greater than 50 db loss at 2000 Hz in best ear after correction	• Special mirrors and day time only

Table 5. (Continued)

Source	Hearing Loss Characteristics	Restrictions
Commercial Vehicle		
USDHEW Public Health Service (1969)	"Hard of Hearing" on voice recognition test	• Two side mirrors plus successful completion of deaf driver course
Quebec Department of Transport (1973)	• Greater than 40 db but less than 60 db average loss in right ear. Greater than 50 db but less than 60 db average loss in left ear at 500, 1000, and 2000 Hz	• Can not drive public vehicles where chauffeur must speak to passenger, e.g., bus driver or taxi
	• Greater than 60 db average loss in each ear at 500, 1000, and 2000 Hz	• Can not drive public vehicles or vehicle over 6000 lb.
	• Normal hearing in one ear only	• Can drive public vehicles without passengers
Canadian Medical Association (1974)	• Greater than 40 db loss on 1964 ISO scale at 500,1000, and 2000 Hz on pure tone audiometer in either ear	• Should not drive passenger carrying vehicle
	• Greater than 40 db loss on 1964 ISO scale at 500, 1000, and 2000 Hz in both ears	• Should not drive heavy commercial transport vehicle

communication. The severity of this problem is related both to the degree of hearing loss and to the age at which the person first became impaired (Kirk, 1972). The earlier the loss and the later formal education begins, the more difficult all communication becomes. There are a number of driver education programs specifically designed to teach the deaf driver. These range from primarily classroom driver education curriculum modification with additional captioned visuals (Cunningham, 1970) to ones with special in-car changes in dashboard lighting (Champagnez, 1975). Often these programs rely on practice with simulators to minimize hazardous first time behind the wheel experiences. Special counselling may be necessary to some new drivers, especially those suffering from prelingual or progressive hearing loss (Garrett and Levine, 1972).

Mechanical driving aids for the hearing impaired are not elaborate. Conventional hearing aids may be of some value in the operation of a private vehicle but is generally of little help in improving the hearing of the driver of a noisy passenger transport or commercial vehicle. Probably the best aids currently available to the hard of hearing are the addition of both right and left outside mirrors and public information sources which give guidelines for compensatory activities such as having a hearing passenger when driving unfamiliar routes and making frequent checks on possible mechanical problems. One which might be particularly useful is *Tips on Car Care and Safety for Deaf Drivers* available through the U.S. Department of Transportation, National Highway Traffic Safety Administration.

SUMMARY

Vision

In summary, the literature indicates that vision deficiencies probably have an adverse effect on safe driving performance. Part of the problem of showing this relationship has been the over emphasis on static visual functions rather than dynamic visual functions which are more likely to reflect the individuals visual capabilities most important to safe driving performance. The fact that the severely visually impaired driving with the aid of telescopic lens spectacles have fewer accidents than the general population is probably due to non-visual factors. One of these may be that the wearers of the bioptic telescopes drive less than the general population and probably exercise certain self restrictions such as driving on familiar routes, limited night driving, and driving at time of day when traffic is light.

Another obvious factor is the selection process which tends to be biased against the handicapped driver, in general, and which is particularly true with the low vision individual. The states that do license drivers with bioptic aids require they do so with a vision care practitioner's approval. Fineberg's rehabilitated drivers with bioptic aids are only 300 out of 10,000 individuals that he has rehabilitated to wear the bioptic for other purposes. The Telescopic Lens System and Driver Licensing Symposium participants for the State of New York concluded last year from the information available, that certain wearers of bioptic telescopic spectacles who have managed to survive this pro-ess can drive safely and should be given the opportunity to be licensed. The impact of easing licensing requirements which would allow greater

numbers of low vision individuals to drive is not very clear. Finally, although NHTSA is doing considerable amount of work in this area, at the present time there is still insufficient research data to establish fixed vision licensing standards. Hopefully this will be solved over the next few years.

The types of research currently being sponsored by the NHTSA are listed in Table 6. What we are doing is by no means covering all that needs to be done. We encourage continuing research and development by the other agencies and we hope to stimulate a whole new area of vision research at universities and other institutions with respect to dynamic vision and driving for all drivers as well as work directed toward the severely visually handicapped.

Further research is needed, first to determine which visual functions in addition to static visual acuity are most critical to driving performance, and what cut-off scores are reasonable for standards in restricting driving or referral to low vision practitioners. Additional research should also be pursued in the development of training techniques or methods of compensating for visual limitations, particularly those which relate to useful peripheral vision and perception of movement to complement specific training in the use of the bioptic in driving.

Audition

With regard to hearing disorders, it must be pointed out first that the auditory requirements for safe driving have not been established. It seems obvious that hearing is useful for driving, but may not be necessary if the hearing impaired driver is aware of the deficiency and

Table 6. Recommended R & D (Vision)

- Experimental collection of basic data on new visual/perceptual parameters
- Exploratory development of instrumentation for collecting the basic data and generating standards for instrumentation design
- Development of techniques and clinical methodology for improving dynamic visual/perceptual abilities or compensatory activities
- Further research to determine which visual functions are most critical to safe & efficient driving performance
- Development of licensing standards based on above for low vision cut-off scores, test-retest requirements, and referral to Special Improvement Programs

learns to compensate. Some studies have shown the possibility of over-involvement in accidents due to hearing disorders, but generally there is little evidence available. When considered with findings of Henderson and Burg that noise may mask some of the important warning sounds even of the normal driver, it appears that more emphasis should be placed on education and training for ways to compensate for inability to hear than to place rigid standards on restricted licensing of the deaf.

Some of the research and development recommended to aid the hearing impaired are given in Table 7. No state prohibits licensing of deaf individuals for passenger car operation, but there is obviously a great deal of research which needs to be done with the hearing impaired and driving performance, particularly in commercial vehicle operation. Considerable work still remains to be done in determining what auditory requirements are necessary for driving safely in order to develop driver improvement programs which will be of most benefit to persons with hearing loss. As with most handicaps, there are many with the handicap who would like to drive, but don't because of the difficulties of getting a driver's license. To aid this process, standards should be developed for both defining what is a serious hearing loss for safe and efficient driving and what restrictions if any should be imposed by the State Departments of Motor Vehicles. The most important research needed, however, is in the area of driver education and improvement. As greater numbers of education and training courses are made available to the hearing impaired, they should be centered around developing and improving those skills most critical to safe driving performance. What those skills are however, and what training techniques would be effective are at present largely unknown.

Table 7. Recommended R & D (Audition)

- Establish auditory requirements for safe driving performance
- Development of standards which define serious hearing loss relative to driving
- Research and development of new techniques to improve or compensate for hearing deficiencies
- Development of techniques to improve communication with hearing impaired relative to driving
- Development of R&D program to develop licensing standards for commercial vehicle operators
- Develop driver education programs for deaf based on safe driving performance skills

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A PROPOSED PLAN FOR CONTINUED PROGRESS

Edward Peizer

An inter-agency group representing the Veterans Administration, the Rehabilitation Services Administration, and the Department of Transportation have proposed a plan for a comprehensive and progressive program to attack problems of providing optimized personal licensed vehicles for the disabled. Presented here today were a variety of devices, systems, and total automotive configurations representing to some extent the state of the art. No one today believes that we have achieved fully adequate levels of safety and fail-safe function in vehicle design, access equipment, control systems and vehicular accessories. The variety of potential drivers, and the relatively large numbers of differently designed components and systems combine to make the problem of optimization difficult. No one solution is likely to emerge. At this time perhaps the best we can hope for is the development of a systematic approach to matching a particular handicapped person and the particular set of components and systems representing an optimal combination which will operate adequately in different situations.

These goals cannot be reached by roundtable discussions and by intellectual tours de force. Achievements of this kind can only be the product of accurate problem identification, judicious consideration of available options, selection of the most promising approaches, testing, and evaluation. A procedure of this order not only requires money and expertise but perhaps a most precious ingredient - time.

The Interagency Committee on Automobiles and Adaptive Equipment, Research, and Development have proposed a plan for a systematic attack on these problems over a period of 5 years from fiscal year 1977 through fiscal year 1981. Reference to the plan for licensed transporters for the handicapped (Appendix 1) describes the approach to vehicle design.

A. LICENSED TRANSPORTERS (Appendix 1)

1. Vehicle Design

a. Electrically driven vehicles permit extensive variation in the configuration of automobiles. It is considered useful to evaluate them for the use of the handicapped. This may permit radical redesign of driver compartments and entry features permitting the use of ramps rather than lifts. In this connection it is proposed to evaluate present designs, develop optimized configurations, evaluate them, develop standards for electric vehicles if proven successful and generate an industry which will produce them commercially.

b. The whole intent of the program must include consideration of the vocational potential of enabling handicapped people to drive. Not everyone, handicapped or not, is capable of or wants to be a brain surgeon or computer operator. Driving is known to be intrinsically satisfying to people who have lost the ability to displace their bodies normally, and driving is an inherently satisfying activity. This creates a vocational opportunity in which a person can turn an inherently pleasurable activity into gainful employment. For this reason we propose to evaluate the vocational utility of current vehicles,

redesign them for special vocational applications, evaluate the vocationally inspired vehicles, develop standards of safety and function, and evaluate both a clinical and economic value of such a program.

c. Despite the recidivism of the general public in using large cars with higher gasoline consumption, it would appear that the future points to vehicles that consume less fuel and produce fewer pollutants. The development of compact vehicles designed specifically for use of the handicapped population is also considered a sensible goal.

2. In the area of access equipment, we must consider safety, function, and prescription indications for elevators, transfer devices and access systems in general. We propose to evaluate the existing systems, redesign, test, optimize and produce them.

a. A first consideration is the seat from which a handicapped person drives. There are at present two different approaches to this problem. Certain vans are designed to be driven by a driver sitting in the wheelchair he normally uses when not driving. The Drive-Master, the Helper, and perhaps six to eight other commercially available van configurations are designed in this way. The driver enters the vehicle via the access system, propels his otherwise generally used wheelchair to the driving position, and secures the wheelchair by one of several methods. These methods include attaching a hook which is in turn attached to the floor of the van, to the cross frame beneath the seat of the wheelchair and taking up the

slack by means of a turnbuckle or a screw. In addition to several variants of this basic idea are several other mechanical and electric fasteners which engage the vertical member of the chair above the caster by a spring-loaded or solenoid-controlled mechanism. While all of these serve in one way or another to secure the chair under certain circumstances, how they would behave in sudden stops, sharp turns or in minor impacts is unknown. Being fastened at one point or even possibly two by any of the systems mentioned above does not appear to offer adequate security.

The second approach to this problem has been to use a special chair for driving. This approach has two variants. In one, the driving chair is usually a relatively heavy, electrically powered chair with a sturdy steel base which may be fastened by any of the methods described above in combination with detentes in the floor into which the wheels of the chair are driven, increasing the resistance to rocking and rolling out of position as the vehicle moves. One unit, the PRAHN wheelchair, is capable of being reconfigured to adjust height and back and leg rest attitude to facilitate the driving. Several other similar versions are available, including one from Rancho and another one from the Sevier Company. These are essentially heavy duty electric wheelchairs and are therefore non-folding and do not meet the same requirements as the conventional, manually-controlled wheelchair. Another variant of the "special chair" approach is that embodied in the

Roycemobile, the roll-in seat. This device is essentially a small wheelchair-like seat attached to the left hand side of the van by the engagement of a roller in a track so that the seat can displace along the range of the left side of the van from the driving position to the rear of the vehicle. The user enters the van in his normally used wheelchair, transfers to the roll-in chair and then pulls himself forward into the driving seat which he latches by means of two locks when he arrives. This system requires a patient who can effect the transfer from his own chair to another one, pull himself manually along the side of the van in the tract roll-in chair and operate the security latches. While this system enables another person to drive the van from the roll-in seat, a completely satisfactory solution about what to do with the chair in which the patient entered has not evolved. This whole idea needs clarification and development, particularly as regards driver seating.

b. We propose to evaluate existing access systems (Appendix 1). There are at least 10 and possibly more elevator systems designed to enable a wheelchair using patient to enter a van either as a passenger or as the driver. In general there are four basic types. There are rear loaders such as the Motorette; side loaders such as the Compass and the Roycemobile, and another side loader which rotates 180 degrees such as that seen in the Helper and Drive-Master vans. The fourth type is the Sevier Company's floor bed type which lies beneath a

built-up floor. When actuated, it extends to the rear (or to the side, if desired) and configures itself into a platform which lays on the road or the curb. Extensive engineering studies are being conducted at Texas A&M University on the safety, design adequacy and mechanical function of each of these systems. At the same time, as shown in Appendix 1, clinical studies are under way in which vans equipped with each of the types of lifts described above are being used by patients under the supervision of designated driver trainers.

Other entry/exit systems for autos which may eliminate vertical lifting by the use of ramps are to be considered. Certain French vehicles may have an automotive configuration which "kneels," enabling a wheelchair user to enter the vehicle by going up a ramp and then powering the rear wheel vehicle back up into the driving position.

3. Control Systems

a. It seems appropriate at this time to plan a continued program of compliance testing to assure the quality of currently available types of mechanical hand control systems.

b. For want of a better term we propose the establishment of "Checkout Facilities" which are essentially services made available in at least 8 hospitals around the country to serve as automotive centers. These units would be staffed by people expert in automotive design, development, prescription, maintenance, evaluation of installation quality, and other factors

relating to automotive use. These centers would not only provide services to handicapped persons but also provide advice to other less expert groups as needed.

c. With the advent of servo systems, an effective program to evaluate them should be established. We need to know the characteristics of these new systems as regards safety, reliability, economy, and effect on the total vehicular configuration. As we view the 4 or 5 different systems now available, it is not too difficult to imagine reconfiguring the driver's compartment completely to eliminate steering wheels and steering columns and pedals. Dashboards can then be rearranged and the entire compartment designed for safety, comfort and better vision. Having seen these systems demonstrated it is quite clear that a great deal of testing and evaluation is required and perhaps redesign, before one can consider the Volvo, the VAPC, the Scott, the Sevier, the CCI-Harden systems, and the NASA-VA lunar rover, ready for use by the general handicapped public. These novel systems seem quite sound from an engineering viewpoint. It remains to be seen whether they can stand the test of long and hard usage normally given to automotive vehicles. This will be accomplished by extensive testing at the TAMU and other facilities such as the new RSA Center under Professor Pearson in Michigan and by extensive field evaluations in cooperation with the PVA and other veteran consumer groups. After extensive testing under safe conditions and adequate assurances that the control systems

and vehicles are road-worthy, certain numbers of these vehicles will be made available to veteran groups, perhaps on contract, to road test them extensively. If the results of the road tests warrant, standards and specifications will be formulated governing the safety and quality of servo controls for automotive vehicles.

4. Accessories

a. Although we have discussed the security of the wheelchair using driving in the van, we have not yet mentioned an equally significant problem, that of the wheelchair user as a passenger in a vehicle, and his need for secure fastening. The problem here may be more difficult than for the driver since the non-driving passenger may be too severely disabled to drive himself, implying that he lacks sufficient arm strength to grasp any holds to prevent injury due to inertial changes. Here we have a wide open field for development since we know of no fully adequate systems to secure wheelchair passengers. Obvious approaches, of course, are tie-downs that secure the chair combination with lap and shoulder belts. But here we come against the problem of a chair and its lack of resistance to collapse even in the smallest impacts. On the other hand, for passengers there may be an addition in that the driver may not be handicapped and devices designed for an able bodied person to use may be somewhat easier to approach than those for wheelchair passengers themselves to use.

b. Obviously automobiles are not immune to mechanical failure but the solution available to the rest of us is not available to the handicapped. In many cases they cannot leave the vehicle if power is lost, creating a need for well designed, reliable communication devices which may have to be independent of the vehicular power system.

5. Driver Assessment. As discussed earlier, studies of the functional capabilities of the disabled to drive had been considered important in the past but are now essential. On the one hand we need reliable prescription indications in order to obtain an optimal match between any driver and any vehicular configuration. On the other hand we need to know the extreme limits of disability beyond which a person should not drive, particularly in relation to the state of the art at any given time.

6. Vocational Rehabilitation. Ability to use a vehicle may possibly place employment within reach of a handicapped person whose skills, background and interests lead him to vocational opportunities which require driving. In this connection we must determine the range of vocational options related to driving, i.e., employment as a driver. We must also consider adaptations of available vehicular systems for those who simply need transportation to and from work but face problems between the vehicle and the work site.

7. Driver Training. Many driver training programs have done great work in teaching handicapped persons to drive with adaptive equipment. There is however a great deal of variability in training philosophy, methodology and technique. Standards must be established and adequate training facilities must be developed. The driver training programs need

to be established to familiarize a corps of driver trainers in newest control systems, access systems and other developments.

The tasks described above and the plans proposed to launch an effective attack on them require time, money, personnel and perhaps most important, a high degree of cooperation and coordination of work among all interested agencies. At this time VA, RSA of HEW, and the DOT plan to take the steps presented above.

APPENDIX 1

LICENSED TRANSPORTERS FOR THE HANDICAPPED DRIVER

CATEGORY	F.Y. 1977	F.Y. 1978	F.Y. 1979	F.Y. 1980	F.Y. 1981
1. VEHICLE DESIGN a. Electrics b. Vocational Configurations c. Compacts	a. Evaluate Elec.Vehicles b. Evaluate Voc.Utility of Current Vehicles c. Evaluate Compact Vehicle for Disabled	a. Develop Elec.Vehicle b. Develop Special Vocational Configurations c. Develop Compact Vehicle	a. Evaluate Special Designs b. Evaluate Vocational Utility of new designs c. Evaluate Compact Vehicles	a. Standards for Electric Vehicles Inspection and Qualification b. Standards for Vocational Vehicle Inspection, Qualification c. Develop Inspection, Qualification and Licensing Regulation for Compacts	a. Commercial Production of Electric Vehicles b. Clinical and Economic Eval. of Automotive Voc. Rehab. Project c. Develop Standards for Compacts d. Review Standards for Voc. Vehicle & Elec.Veh.
2. ACCESS EQUIPMENT a. Elevators/ Lifts, Transfer Device, Access Systems	a. Evaluate Royce-Type Driving Seat b. Evaluate PRAHN, and Rancho Type Driving Seat c. Evaluate Van Lifts d. Evaluate Other Entry/Exit Systems for Autos	a. Develop Transfer Type Driving Seat b. Develop Powered Modular Driving Seat c. Evaluate Van Lifts; Establish Standards d. Evaluate Configurations of Ramps, Overhead Lifts, Sliding Seats, Door/WC Entry Systems Available	a. Evaluate all New Driving Seats b. Van Lift Compliance Test c. Optimize Designs and Make Prototypes d. Review standards for lifts	a. Develop Rx indications and Safety Requirements b. Evaluate New Lift & Seat Systems	a. Develop Standards for Seats b. Compliance Testing of Lift and Seat
3. CONTROL SYSTEMS	a. Continue Compliance Testing on Mechanical Hand Controls b. Establish two Checkout Facilities c. Evaluate Servo Systems, Volvo CCI-Harden, VAPC, at Texas A&M and Selected Stations d. Review Standard for Hand Controls	a. Continue Compliance Testing on Mechanical Hand Controls b. Establish two Checkout Facilities to make 4 total c. Field Evaluation of Servo Systems	a. Continue Compliance Testing on Mechanical Hand Controls b. Establish two Checkout Facilities to make 6 total c. Continue Field Evaluation of Servo Systems	a. Continue Compliance Testing on Mechanical Hand Controls b. Establish two Checkout Facilities to make 8 total c. Develop Standards for Servo Systems	a. Continue Compliance Testing Mechanical Hand Controls b. Commercial Production of Servo Systems c. Review Standards for Servo Systems
4. ACCESSORIES	a. Evaluate Communication Devices b. Evaluate Methods and Devices for Securing WC's and Passengers in vehicles	a. Develop Communication Devices b. Develop Improved WC and Passenger Security Devices	a. Deploy Communication Devices for Patient Use b. Deploy New Wheelchair and Passenger Security Devices for Evaluation	a. Develop Communication Device Standards b. Develop Wheelchair and Passenger Security Device Standards	a. Compliance Testing of Communication Devices b. Compliance Testing of Wheelchairs c. Review Standards for Communication Devices and Wheelchair and Passenger Security Devices
5. DRIVER ASSESSMENT	a. Studies of Functional Capability of Disabled to Drive, Classification of Driving Potential	a. Determination of Optimal Vehicular Configuration for Driver Classifications b. Development of Driver/Vehicle Interface Adaptive Devices in context with new servo systems	a. Evaluation to Determine Validity of Rx indications b. Evaluation of New Devices	a. Develop Rx Standards	a. Program with DOT and State Licensing Agencies to Establish Standards b. Review Rx Standards
6. VOCATIONAL REHAB.	a. Determine Range of Vocational Options Related to Driving	a. Test Programs Providing On-The-Job Training Using Adapted Vehicles	a. Develop Employment Profiles for Disabled who can Drive	a. Establish Vocational Rehabilitation Program to Employ Disabled Drivers	a. Expand Vocational Rehab. Programs to Employ Disabled Drivers
7. DRIVER TRAINING	a. Establish Programs to Train Driver Trainers on new systems	a. Establish Driver Trainer Training Programs using new systems		a. Establish System-Wide Training for Users of Adapted Vehicles	a. Establish Qualification Standards for Trainers b. Establish Licensing Standards for Disabled

APPENDIX 2

NON-LICENSED TRANSPORTERS

	F.Y. 1977	F.Y. 1978	F.Y. 1979	F.Y. 1980	F.Y. 1981
1. MANUAL WHEELCHAIRS	a. Development of Custom Molded Back/Seat b. Parapodium/wheelchair Development c. Evaluation Prast Parapodium d. Evaluation of New Wheelchairs	a. Evaluation of Custom Molded Back/Seat b. Evaluation and Modification Parapodium/wheelchair c. Modification and Reevaluation Prast Parapodium d. Evaluation of New Wheelchairs	a. Evaluation of Custom Molded Back/Seat b. Clinical Evaluation on Parapodium/wheelchair c. Clinical Application Prast Parapodium d. Evaluation of New Wheelchairs	a. Develop Standards Custom Molded Back/Seat b. Develop Standards for Parapodium/wheelchair c. Evaluation of New Wheelchairs	a. Compliance Testing b. Evaluation of New Wheelchairs c. Review Standards for Seats and Parapodium/wheelchair
2. POWERED WHEELCHAIR	NELC 3-Module System: a. Evaluate Stand-up Wheelchair b. Evaluate Prototype Ambulator (6) c. Modify Prototype Ambulator d. POWERED WHEEL SYSTEMS: Evaluate Photocircuits Powered Wheelchair Evaluate Litters Evaluate Dudley Powered Wheelchair	a. Clinical Application Study WC/AMB System b. Develop Standards for Powered Wheelchairs	a. Evaluation of Prototype 3-Module System b. Develop Compliance Test Program for Powered Wheelchair c. Review Standards for Powered Wheelchairs	a. Clinical Application 3-Module WC/AMB/Auto System b. Compliance Testing	a. Develop 3-Module System b. Compliance Testing
3. ALLTERRAIN VEHICLES	a. Evaluate of New Wheelchairs b. Evaluate Allterrain Vehicle: General Teleoperators Allterrain c. Wheelchair, Everest & Jennings I/O Wheelchair	a. Reevaluate Modified Allterrain Wheelchair Design b. Evaluate New Allterrain Wheelchairs	a. Clinical Application of Allterrain Wheelchairs	a. Develop Standards for Allterrain Vehicles	a. Compliance Testing b. Review Standards
4. WHEELCHAIR CONTROL SYSTEMS	a. Develop Pneumatic System b. Develop Telemetry System	a. Evaluate Pneumatic System and Optimize b. Evaluate Telemetry c. Research New Forms of Control	a. Clinical Application Pneumatic System b. Clinical Application Telemetry System	a. Develop Standards for Pneumatic and Telemetric Systems	a. Compliance Testing b. Review Standards
5. WHEELCHAIR ACCESSORIES	a. Develop Electric Brakes b. Develop Automotic Transmission	a. Evaluate and Optimize Electric Brakes b. Evaluate and Optimize Automotive Transmission	a. Clinical Application b. Clinical Application	a. Evaluate New Accessories	a. Evaluate New Accessories b. Develop Standards
6. [illegible] DEVICES FOR EVALUATION					

SECTION III. PANEL REPORTS

REPORT OF PANEL I

Lewis A. Leavitt, Chairman, 1st Day
Douglas Hobson, Chairman, 2nd Day

Paul Brainin
John DeLellis
Uno Gunnelid
Ake Hansson
David Hardin
Paul Hill
Ralf Hotchkiss
Verne Houston
Slade Hulbert
James Kelley
Shawn Solomon (Part Time)
Warren Smith

Appreciation is expressed to the members of the panel for their participation and their valuable resources of information. The knowledge and expertise expressed by these panel members was impressive. Special appreciation is given to Mr. Uno Gunnelid, a representative of A.B. Volvo Car Division from Goteborg, Sweden, and Mr. Ake Hansson from the Swedish Rehabilitation Institute, Stockholm.

Report of the First Day

The panel considered the disabled driver (primarily as a quadriplegic, paraplegic, hemiplegic, and amputee) and special problems that would relate to access-egress, vehicle control, communication, safety, driver assessment, driver education and training, and licensing procedures.

After some discussion, it was agreed that the following issues would be considered first:

1. Specific disability category needs.
2. Assessment and evaluation of the disabled individual.
3. Driver education and training.

4. Research and development needs for the disabled driver.

5. Delivery systems.

Particular recommendations and comments are set forth under each of these issues:

I. Specific Disability Category Needs:

A. Quadriplegia

1. Develop vehicle and servo system specifications for the quadriplegic. Specifications should include forces needed to activate the controls and should cover the necessary built-in safety factors provided by secondary or backup systems.

2. Investigate the need for finer control of temperature and humidity by the quadriplegic driver in a conventional or modified vehicle.

3. Investigate the effects of dynamic loading of tissue while in the driver's seat. This study is necessary because of the spinal cord individual's difficulty to change his weight distribution for tissue pressure relief while his arms and hands are occupied operating the vehicle controls.

4. Investigate potential problems arising from emergency situations encountered by a quadriplegic driver alone in a modified vehicle.

B. Paraplegia

1. Study the energy requirements for entrance and exit as well as loading, unloading, and stowage of a wheelchair.

2. Determine the best available conventional automobile to meet the paraplegic's requirements for entrance, exit, seating, independent wheelchair stowage, and appropriate driving controls.

3. Determine at what level of paraplegia a van becomes more desirable than an automobile.

C. Hemiplegia

1. Establish a specialized program at a neurological disease oriented center to undertake further research and development in driver evaluation, education and training for this population. Unless the capabilities of this population to drive an automobile can be identified, hemiplegics will continue to experience the practice of having to wait at least six months post-onset for stabilization before being permitted to enter a driver training program.

2. Disseminate information concerning specific devices and training methods for the hemiplegic to other driver programs.

D. Amputation

1. Inform driver education and training programs of the specific functional abilities (relating to the driving act) at the various limb amputation levels with respect to the appropriate prosthetic devices.

2. Study older amputee drivers to determine the prevalence of cognitive and perceptual deficits.

II. Assessment and Evaluation of the Disabled Individual:

A. Develop a standardized evaluation procedure. Such a method or procedure should be functional with respect to the driving act and include, for example, range of motion, muscle strength, coordination, perceptual skills, etc.

B. Form a multidisciplinary team consisting of a physician, engineer, therapist (corrective, occupational and/or physical), driver educator and trainer, and psychologist or social worker to assess and evaluate disabled individuals to be drivers.

C. Determine and establish levels of functional impairment beyond which a disabled individual should not be considered for driving.

D. Define the psychomotor aspects of the tasks of driving.

E. Develop a closed loop simulator and validate its usefulness for evaluation, assessment, and training of the driver. More simple closed loop simulators could then be made available for the various multidisciplinary teams providing driving programs.

F. Establish a data bank of categories and numbers of disabled people needing special programs for driving licensed vehicles as well as available and appropriate equipment.

III. Driver Education and Training:

A. Develop a standardized driver education-training program.

B. Describe the state-of-the-art.

C. Designate the driver educator-trainer as a member of the evaluating team.

D. Incorporate a closed-loop simulator (once its validity is determine) into the driver education-training program prior to actual training in the vehicle

E. Educate the driver educator-trainer nationwide through a series of workshops.

F. Use "performance evaluation" as the basis for the program.

G. Document driver educational-training programs as a part of a data bank and formulate data on types of individuals successfully completing driver programs, their employability, their vocational goals, their rate of accident, licensure, insurability, etc.

H. Standardize the tasks needed to be accomplished on the driving range.

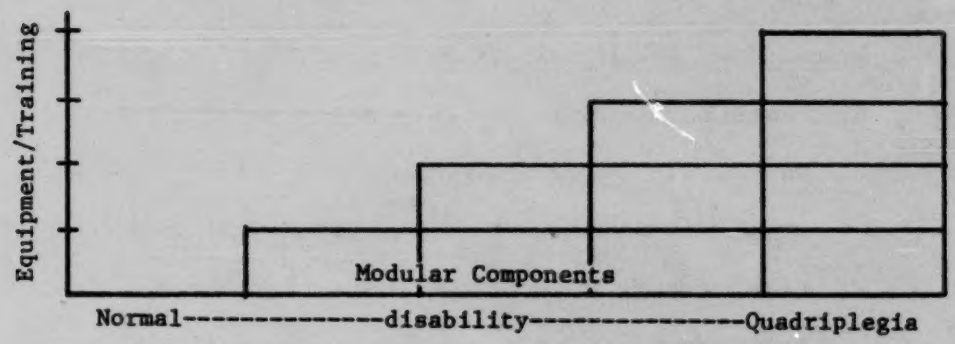
IV. Research and Development Needs for the Disabled Driver:

A. Design a specialized wheelchair from which a disabled individual would drive. Such a wheelchair should have a contoured seat to provide truncal support and permit dynamic loading of tissue, be either manual or powered in operation, have a variable height, permit entrance and exit into van or transfer to conventional driver's seat and permit entrance and exit to a modified vehicle (other than a van) to function as a driving seat, etc.

B. Research and develop control systems that would have adequate built-in safety features to permit licensure and qualification for insurance coverage. The present servo-control systems, as demonstrated during the workshop, are very innovative but need considerable additional design to meet the safety requirements that would be acceptable from a liability viewpoint.

C. Develop modular driving components built to specific design specifications for the disabled driving population (note graph). The graph indicates that the normal driver should be able to drive a conventional automobile with no adaptive equipment and would have full functional capabilities. As a disabled individual's functional capability decreases, there is need for

additional equipment and training if the individual is to drive a modified vehicle in a safe manner and to obtain a license and insurance and to decrease liability for the total program and sponsoring agencies.



D. Determine the cost/benefit of providing transportation to a disabled individual that would permit his employability.

V. Delivery Systems:

A. Determine a more specific role for the supplier. At this time many suppliers are also the providers, evaluators, assessors, and trainers. If the supplier is not a member of the evaluation and assessment team, then close liaison should be established with him.

B. Establish an equipment provision system at national, state, and local levels once the equipment has passed a rigid criteria for safety.

C. Recommend that the evaluation team complete a specific prescription of necessary equipment for the disabled individual to result in an

acceptable man-machine interface. All prescribed vehicle modifications should be accomplished by the clinical engineer or under his supervision.

D. Establish an equipment maintenance program.

Report of the Second Day

During the second day, the panel attempted to focus on three issues which included the four vehicle categories (conventional automobiles, vans, powered wheelchairs, special systems) suggested by the Steering Committee. These three issues were:

1. "Off-the-shelf" items.
2. Future research and development activities.
3. Program planning (proposed five-year plan).

As might be anticipated, both recommendations and comments were made.

I. "Off-the-Shelf" Items:

A. Conventional Automobiles

1. Encourage Volvo to consider the problem of independent wheelchair stowage by the disabled driver, and Ford to continue its developments in this area.
2. Explore establishing standard designs which would make the conventional automobile more readily adaptable for the disabled driver. Such areas as a standardized attachment bracket for hand controls, or providing a wider door opening in a larger range of models are examples of areas that may be investigated.

3. Evaluate the Ford concept of a strap from the rear of the front seat to the control panel for adding additional safety for the paraplegic during the transfer process to determine its applicability for use in other standard automobiles.

B. Vans

1. Investigate the desirable features of the step-van type vehicle for use by the independent wheelchair driver.
2. Determine the type and extent of backup or redundancy systems that will be required to insure the safety of a disabled driver who is operating a modified van independently.
3. Encourage the representatives from the automobile industry to consult on safety and structural integrity aspects when modifications to standard vans are being considered.

C. Powered Wheelchairs

Develop performance, safety, and design criteria for powered wheelchairs and make the criteria available to prospective developers and/or manufacturers. In developing these criteria, close cooperation should be established with agencies such as UMTA and FDA so that designs will meet present and future safety standards for urban and interstate public transportation.

D. Special Systems

1. Consider CB radios and telephone dispatch as an integral part of the future vehicles for the disabled in order to insure driver safety.
2. Provide a manually deployable trouble indicator in order to attract assistance in the event of a total system failure of the adaptive vehicle.

II. Future Research and Development Activities

A. Conventional Automobiles

1. Evaluate and make available the Rehabilitation Institute of Detroit servo control system of the accelerator and brake as an alternative to the mechanical hand control systems. In addition, this system should be developed further to include servo control of steering that can be added to a conventional automobile or van.

2. Design and develop a sedan type sub-compact vehicle that would be used by the general public, but could have options which could be readily adapted to meet the special needs of the wheelchair driver.

3. Assist the automobile industry and/or participating research laboratories in their efforts to develop and market equipment for the disabled driver. This could be accomplished by the three coordinating federal agencies (VA, DHEW, DOT) by assuming the responsibility for establishing performance criteria and gathering statistical information on the number of individuals requiring special vehicles or adaptive equipment.

B. Vans

1. Direct more investigation at the problem of safety by the disabled driver in operating a modified van.

2. Develop an "add-on" "off-the-shelf" wheelchair tie down system that will meet automobile (van) safety standards.

C. Powered Wheelchairs

1. Develop a collapsible power wheelchair which can be used independently by a disabled driver in conjunction with a conventional automobile.
2. Design future wheelchairs so that it augments the total mobility needs of the disabled individual in his home, work setting, recreation, community and world-wide travel.

D. Special Systems

1. Develop future generation automobile designs which provide alternate methods of controlling an automobile with the intent that a design would be chosen that would extend the number of disabled individuals that could become drivers of conventional automobiles.
2. Evaluate the many safety devices in the Experimental Safety Vehicle (ESP) for their applicability to meet the special needs of the disabled driver.
3. Investigate alternate approaches to controlling a vehicle such as radar braking and automatic guidance systems.
4. Develop improved disabled transport equipment such as restraining systems and seats for public vehicles such as buses, trains and planes.

III. Program Planning (Proposed Five-Year Plan):

Considerable attention was directed to the five-year interagency proposed plan. It was realized that the plan represents an initial attempt at developing organizational concepts and therefore the following recommendations should be considered as suggestions that may be useful to the program planners.

A. Establish a joint executive committee (VA, RSA, and DOT) to provide direction for the program's needed research, development, evaluation and educational efforts.

B. Apply goal-oriented organizational techniques such as PERT or CPM to the proposed five-year plan. These techniques have proved successful in industry and other government agencies. This approach would assist in interagency communication and program/project monitoring.

C. Recommend that other disability categories such as cerebral palsy, low vision, and other less common motor-sensory dysfunctions be considered in order that their special needs will be accommodated within the overall scope of the program.

D. Include meaningful consumer group participation, placing particular emphasis on psycho-social aspects of hardware design and service delivery.

E. Define the roles of the members of the evaluation and assessment, education and training team.

F. Develop an educational program to train the various disciplines required to deliver the specialized services required by the disabled driver.

G. Shift the programmatic activities in FY 77 and 79 designated "Driver Training" (item 7) over one year to be undertaken in FY 78 and 79 with the added recommendation that evaluation of established driver training programs take place in FY 1977.

H. Develop the delivery system that will be necessary for widespread delivery of the newly developed techniques and devices presently included in the plan.

REPORT OF PANEL II

Ray Cheever, Chairman, 1st Day
Maurice LeBlanc, Chairman, 2nd Day

James Allen (Part Time)
John Cemirys
Grace Cheever
John D. Collins, III
Douglas Haman
Wayne Hansen
Margaret Kenrick
Make McDermott
John Mitchell
George Muller
Steven Reger
Anton Reichenberger
Jiri Sipajlo
Melvin Stills

Report of the First Day

The matrix suggest in the May 12 memorandum to panel chairman (see preface) was followed. Thus, the state-of-the-art and the needs of the quadriplegic, paraplegic, hemiplegic, and amputee were considered with respect to vehicle types. Specific recommendations were offered. A "requirements matrix" was developed to summarize the information generated by the panel.

I. State-of-the-Art:

A. Quadriplegia

1. Some quadriplegics require assistance in entering and leaving an automobile. Sliding boards have been devised that can be used independently by some, but often personal assistance is required with the aid of a hoist.
2. Obviously, the van configuration presents less obstacles to use by a quadriplegic than an automobile.

3. The ultimate goal in mobility for the disabled such as a quadriplegic is a system that provides all activities that are to be undertaken from the time of getting out of bed in the morning to going to bed at night - rising, toileting, eating, travel to work, mobility on the job, return to home, mobility in home, recreation and immediate environment, and retiring.

B. Paraplegia

1. Hand controls permit paraplegics to operate an automobile safely. Bench-type seats make transfer easier. The wider doors generally used in two-door models make loading the wheelchair easier. Wheelchair loading is facilitated by the introduction of a false, level floor in the rear compartment when a driveshaft tunnel is present.
2. "Cruise" controls have been found to be helpful to many paraplegic drivers.

C. Hemiplegia

1. Right hemiplegic patients with communication difficulties usually present more of a problem than those whose left side is affected.
2. Driving aids developed for amputees are generally satisfactory for hemiplegic drivers.
3. A fixed handle above the door helps in entering and leaving the automobile.

D. Amputation

1. Unilateral amputees, whether upper or lower limb, can usually operate an automobile with no or few adaptations, especially

when the automobile is provided with automatic transmission and a prosthesis is used. Left foot accelerators, driving rings and other inexpensive mechanical aids are available for those who desire or need them.

2. When one upper and one lower limb are missing, adequate control of an automobile can usually be obtained with standard commercially available mechanical aids especially if prostheses are used.
3. The bilateral upper-limb amputee with prostheses can drive an automobile with little special equipment, other than driving rings. Custom designs for complete control of an automobile with only the feet have been used successfully in many instances, and the Volkswagen Dasher is available with the "foot controls." This project was a result of the "Thalidomide tragedy."
4. Bilateral partial leg amputees that wear prostheses have few problems in operating a conventional automobile. Partial thigh amputees (and higher levels) are generally provided with the same equipment as for paraplegics. For the amputee, transfer is not usually as much of a problem as it is for the paraplegic.
5. Severely disabled cases involving three or four limbs present more difficult but solvable problems.

II. Recommendations:

A. Quadriplegia

1. Study the insurance problems of quadriplegics in the high-risk age bracket.

2. Provide more "damping" in existing control systems for quadriplegics and paraplegics.

B. Paraplegia

1. Develop guidelines for the selection of control systems to best meet the needs of the paraplegic.
2. Study the seemingly retarding effect of the product liability laws on the design and production of control systems. Recommend new legislation to correct this situation if indicated.
3. Recommend widening paraking spaces for wheelchair drivers and passengers.
4. Provide a manual on operation, installation, and maintenance with each control system marketed.
5. Design a stronger wheelchair to meet DOT specifications.
6. Recommend that DOT/EPA establish a fuel consumption waiver program in the case of disabled drivers.
7. Devise a preventative maintenance program at the state level for all special control systems.

C. Hemiplegia

1. Develop the means to determine the "differences" between right and left hemiplegia. This study would lead to improved assessment techniques for the potential hemiplegic driver.
2. Develop controls that "over- and under-compensate" in order to eliminate deficiencies of this driver population.

D. Amputation

None.

III. Motor Vehicle Disabled Driver Mobility Requirements Matrix:

A "requirements matrix" (see Attachment D) was prepared by the members of the panel with specific contributions from Jiri Sipajlo and George Muller.

Report of the Second Day

It was decided by the panel that the state-of-the-art and specific recommendations would be considered with respect to: basic vehicles, entry-exit and seating, control, delivery systems, and cost-benefit.

I. State-of-the-Art:

A. Basic Vehicles

1. Conventional automobiles can be used when the driver is capable of transferring from a wheelchair.
2. Vans can be used when the driver is not capable of transferring from a wheelchair.
3. Non-licensed vehicles (electric carts and wheelchairs) are suitable for neighborhood use and for the transition from home or work place to a licensed vehicle.

B. Entry-Exit and Seating

1. Various assistive devices are available (sliding boards, assist bars, etc.) for help in transfer and in loading a wheelchair into an automobile.
2. Vans are available with a number of features designed especially for the disabled.
3. The non-licensed vehicle like the UCB (Cunningham) design, though not yet commercially available, offers much in entry-exit and seating.

C. Control

1. Available mechanical hand controls for automobiles, as a result of the VA evaluation program, are quite satisfactory from a safety standpoint, although there is still no practical way of insuring proper installation and maintenance on a widespread basis.

   Also available are other special devices such as left-foot accelerators, left-hand gear shift levers, right-hand turn signals.

   Several servo control systems for control of the acceleration and braking are currently being tested, and should be available within one year.

2. Equipment designed for automobiles is equally applicable to vans. In addition extended steering wheels and servo controls for steering are currently in development. The Scott van is the only design on the market now that uses servo controls designed to meet the needs of quadriplegics.

   In development are Sevier, Harden-CCI, Southwest Research Institute, and the French Mirage systems. Various control devices (panels) for other functions (shifting gears, lights, turn signals, wipers, etc.) are available or are being developed.

D. Delivery Systems

In general, there exists no uniform system for most users of licensed vehicles and related equipment. In most cases, when the consumer receives government assistance, it is in the form of

funds to buy equipment with very limited guidance in prescription of equipment. A major problem exists in delivery of information to consumer so that he can make an informed decision. Current sources of state-of-the-art information are consumer magazines like "Accent on Living" and "Paraplegia News."

E. Cost/Benefit

No formal systems-type of cost/benefit analysis that includes the present state-of-the-art is available.

II. Recommendations:

A. Basic Vehicles

1. Obtain, consider, and make available information on the brands and classes of automobiles.
2. Evaluate the efficacy of energy sources for vehicles used by the disabled. Accessibility to the power source (electric and combustion fuels) must be taken into consideration.
3. Implement research on a modular approach to disabled mobility as described by the Mobility Conference held in February 19 4.
4. Provide information on the availability of vehicles for use by the disabled through a data bank.

B. Entry-Exit and Seating

1. Review the mobility problems between the "bed and airplane and back to bed."
2. Research and develop wheelchair tie-down systems in order to provide a safe and standard method to attaching the wheelchair to both public and private transportation systems.

3. Research space, safety and utility requirements concerning problems of entry to the vehicles. Emphasis should be placed on multiple entry-egress capability of each vehicle (side or rear entrance simultaneously) and necessary redundancy of controls with fail-safe designs.
4. Design seating in order to facilitate transfer and access while minimizing tissue damage.
5. Investigate the possibility of using backward facing seating within vehicles.

C. Control

1. Research and develop a device for evaluation of an individual's ability to use the steering wheel, brake, and accelerator with reduced power requirements.
2. Investigate further force and excursion characteristics of driving aids and controls.
3. Research and develop auxiliary control systems in relation to the postural support of the operator.

D. Delivery Systems

1. Establish a center to provide liaison between users, manufacturers, and administrators. The functions of the center should include:
   a. information - review, organize and transmit information.
   b. evaluation - evaluate the suitability of available and potentially available equipment for all concerned.
   c. data collection - gather data on user needs, numbers of users involved, and cost effectiveness of solutions.

d. research and development

2. Establish "Mobility Technology Centers" on a regional basis that would display mobility equipment. The centers would also permit users to test or operate the equipment on a trial basis as well as provide equipment installation and repair.
3. Explore relieving suppliers/appliers of devices from product liability with the establishment of a "Good Samaritan" law.

REPORT OF PANEL III

E'lise Brown, Chairman, 1st Day
James Cockrell, Chairman, 2nd Day

James Aaron
James Allen (Part Time)
Irving Askanas
Mary Barber
Harold Booker
Harry Cheesebrough
Dean Duncan
Geraldine Dickinson
Nils Edwardson
William Freedman
Wallace Motlock
Ron Prior
Larry Ross

Report of the First Day

It was postulated that if the performance requirements of the driving task are known and compared with the capabilities of the individual, feasible systems for driving can be designed, developed, and produced. Costs were not considered by the panel.

The matrix (see preface) suggested by the Steering Committee was used as a guide for discussion and deliberation.

After some discussion, it was agreed that the following issues would be considered: access and egress, vehicle control, communication, safety, assessment, education-training, delivery systems, licensing, and cost.

The following recommendations are offered with regard to the issues.

I. Access and Egress:

A. Review "human factors" affecting vehicle adaptation and design in light of the trend to smaller automobiles.

B. Establish standards for door widths, roof line, and floor line with respect to wheelchair use.

C. Improve wheelchair loading systems for automobiles.

D. Explore the advantages of front-wheel-drive vehicles, with the possibilities for a flat floor.

E. Develop and evaluate bucket seats that can be swiveled, elevated, and depressed.

F. Develop a lift system that is suitable for a wide range of inclines.

G. Improve the reliability of adaptive equipment and alternate back-up systems.

H. Encourage students of schools of automotive design through grants or other means to produce innovative solutions to mobility problems.

II. Vehicle Control:

A. Expand research concerning foot and shoulder steering devices.

B. Consider the "sip-and-puff" system for use in automobile.

III. Communication:

A. Consider routine issue of CB radios to disabled drivers.

B. Explore the use of beacon/emergency radio beeper systems in cooperation with the telephone companies.

IV. Safety:

A. Study the servo systems for reliability.

B. Provide fail-safe stopping systems.

C. Research mirroring requirements as they relate to functional limitations and provide mirroring systems as needed.

D. Improve restraint systems for both driver and passengers.

E. Improve mobile driver seats.

V. Assessment:

A. Use the team approach to develop a battery of tests based on functional task analysis for evaluation of patients with respect to the driving task. Tests covering the following areas should be considered: perceptual, psychophysiological, psychomotor, and performance.

B. Base assessment techniques on the functional task analysis for control within the vehicle and for control of the vehicle in the environment.

C. Give high priority to the development of improved assessment techniques.

D. Identify the levels of impairment when driving is not recommended.

E. Develop a matrix relating functional capability to adaptive devices.

F. Consider in the development of an assessment team physicians from various specialties, therapists, educators, counselors and psychologists.

VI. Education-Training:

A. Include the patient and members of the rehabilitation team within the concept of "educating to the driving task."

B. Develop materials for implementation of recommended curricula for both drivers and driver educators-trainers.

C. Document current methods of driver evaluation and training in the VA.

D. Develop and produce a public relations film concerning the educational-training program.

E. Recommend the name "Driver Training Program" be changed to "Mobility Management Program."

F. Plan uniform curricula and management for existing modes of training (simulator, range, vehicle) as they relate to functional capability.

G. Determine the limitations of existing modes of training and modify them as assessment methods are improved.

H. Establish uniform requirements for the training of educators and trainers.

I. Design assessment instruments based on current modes of training.

J. Develop an evaluation system that will allow for continuous modification of the "mobility management" program.

VII. Delivery Systems:

A. Develop regional centers to provide assessment, evaluation-training, and research. The centers could also serve as training centers for trainers.

B. Establish administrative guidelines in order to provide uniform program development. A reporting system feeding into a data bank should be included.

VIII. Licensing:

A. Recommend that the VA assist other agencies in the development of educational programs for licensing agents concerned with the problems and capabilities of the disabled.

B. Recommend that the VA assist other agencies in developing uniform vehicle licensing and parking programs for the disabled.

C. Explore vocational opportunities through specialized licensing.

D. Eliminate discriminatory licensing practices.

E. Include adaptive equipment in state inspection programs.

X. Costs:

A. Avoid sacrificing safety for cost saving.

B. Include factors concerning rehabilitation costs versus institutional care costs as a part of any cost/benefit studies.

Report of the Second Day

On the second day most of the attention of the panel was focused on establishing the following list of priority projects.

Priority Projects

I. Short Term:

A. Develop a state-of-the-art document which includes a matrix relating hardware to functional limitations.

B. Establish an interagency committee with consultants who would have the responsibility of setting priorities within the overall program.

C. Identify populations that need assessment and driver training.

II. Long Term:

A. Develop and define functional requirements of the driving tasks, both with the vehicle and with respect to control of the vehicle in the environment.

B. Develop assessment techniques for screening potential drivers needs.

C. Study the delivery systems for adaptive equipment with a view toward the development of an efficient method for the provision of quality service.

D. Develop and implement training programs for all staff members.

E. Continue research and development of improved adaptive equipment. Results of this work should be used in the development of standards for performance of adaptive equipment.

F. Establish guidelines for installation, inspection, and maintenance of adaptive equipment.

G. Study the costs of rehabilitation versus institutional care. The results should be used to support any legislative changes that are indicated.

H. Establish educational programs for personnel outside the VA (i.e., rehabilitation counselors and licensing agents).

I. Encourage students of schools of automobile design, through grants or other methods, to design innovative solutions to mobility problems.

REPORT OF PANEL IV

James Maye, Chairman, 1st Day
Samuel McFarland, Chairman, 2nd Day

Roger Koppa
Mary McKenzie
Charles Radcliffe
Joseph Schaeffer
Charles Scott
George Smith
Shawn Solomon (Part Time)
Edward Wasko

Report of the First Day

It was the consensus of the panel that rehabilitation is intended to restore a physically disabled person to the highest degree of functional independence, and the successful attainment of that goal is heavily dependent on acquiring intermediate and long-range mobility. Where braces, prostheses, and wheelchairs have effectively enabled short-range mobility for persons with impaired limbs, the interface to intermediate and long-range vehicles remains to be further developed or enhanced. Despite the imposition of federal directives on buses, trains, and airplanes, travel by these carriers is still unsatisfactory for the disabled. However, even if mass transit modes were optimized for the disabled, there remains a pressing need for more specific destination, schedule free, independent means of urban and interstate travel, as currently possible only by the means of the automobile. Automobile transportation is valuable to the disabled person for at least two major reasons, namely; it expands his communication with the non-disabled population, and it enhances his chances for self-sufficiency and employability. For the supporting family or government agency, it means an improved self-image and reduced economic demand.

The first day was spent formulating a generaly policy statement and policy objectives for the following issues: federal government activities; research, design, and product development; and disabled driver assessment, education, and training.

Policy Statement

Vehicles specifically designed or adapted to enable or enhance the mobility of physically disabled persons constitute a well-developed field of interest in rehabilitation equal in emphasis to either prosthetics or orthotics. The individual knowledge, concern, and professional stature expressed by those persons attending this conference adequately underwrite the need to identify vehicle mobility as a separate and unique field emphasis.

Policy Objectives

I. Federal Government Activities:

A. Coordinate all programs involving mobility of disabled persons through DOT, RSA, and VA as an interagency activity with assistance from non-government organizations.

B. Explore establishing an active and informed influence group (lobby) to press Congress for cognizant legislation and exemptions from existing federal automobile regulations, as they affect the disabled driver.

II. Research, Design, and Product Development.

A. Maintain the concept of "simplicity" as a key feature of all new equipment.

B. Shift research funding priorities in order to emphasize secure seating, safety restraint, and wheelchair stowage in automobiles, vans, and mass transit vehicles.

C. Consider a more total mobility perspective in relation to all equipment and special vehicle design. Design of the wheelchair unit and automobile mobility must be tempered by consideration of all aspects of daily mobility from bed-to-bed.

D. Emphasize increased simplicity and reliability in concert with lower supply costs in the evolutional development of access equipment, control systems, and all other associated accessories.

E. Design all special adaptive equipment with component modularity in mind.

F. Develop and emphasize methods of frequent service and preventive maintenance.

III. Disabled Driver Assessment, Education, and Training:

A. Base assessment of the ability to operate a vehicle on performance after the addition of adaptive equipment.

B. Include comprehensive assessment of emotional and psychological stability as a key element of evaluation.

C. Emphasize defensive driving as a pivotal element of driver education and training.

Report of the Second Day

The panel deviated from the suggested format in formulating its recommendations for improving the mobility of disabled drivers. The panel oriented its suggestions with respect to the following categories: special vehicle design; intravehicle environment; extravehicle mobility, control systems; information processing; assessment, education, and training; and vocational impact.

I. Special Vehicle Design:

A. Impress upon cognizant vehicle designers the unique needs of disabled individuals for mobility.

B. Design and develop a vehicle for the mobility needs for all. The panel felt that a vehicle specifically suited to the needs of the disabled would not be cost effective.

II. Intravehicle Environment:

A. Direct basic research toward acquiring the space needs in the vehicle to accommodate the disabled passenger as well as the disabled driver.

B. Research and design a simple upper torso support restraint to stabilize the disabled driver and protect him in the event of impact.

C. Re-evaluate seating and restraint materials in the light of thermal conductivity, pressure distribution, and surface friction, as dictated by the sensitive and sometimes fragile tissues of the disabled driver.

D. Evaluate the concept of a person riding in a van (or other vehicle) while seated in a wheelchair. Such features as impact resistance and ease of securement should be examined.

E. Evaluate the effective visability of the disabled driver's (i.e. quadriplegic) field of driving. Efforts should be made to relieve any visual hazard from limited neck mobility, higher seated height (wheelchair), and/or folded lift or ramp.

F. Develop a standard emergency package which includes communication links, special lights or signs, fire extinguishers, auxiliary power sources, and first aid equipment.

G. Include with all access equipment, manual features to overcome loss-of-power in order to avoid trapping the disabled occupant.

H. Evaluate the disabled driver's special needs of temperature control. This would include air-conditioning, insulation, sun screens, floor padding, and light colors. Environmental effects of all modifications should be consistently evaluated.

III. Extravehicle Mobility:

A. Develop a manually or electrically powered wheelchair (mobility module) for travel to and from an automobile or van. It should include such features as compact size and weight, padded seating, sturdy attachment (docking) points, separation of seat and mobile base (for transfer).

B. Develop further van lifts and ramps in order to improve reliability, simplify installation, reduce weight, lower costs, and allow access to either side or rear.

C. Explore new passenger transfer methods, wheelchair stowage, and door opening devices for the automobile.

D. Investigate redesign of garages and driveways because of the need for higher doors (vans) and wider lateral space (vans and cars).

E. Develop more reliable and tamper-proof external controls (door openers, etc.) incorporating modern electronic triggering technology.

IV. Control Systems:

A. Continue current developments in sophisticated controls for the disabled driver.

B. Entice the automobile manufacturers to incorporate a universal point of attachment for hand controls on all vehicles.

C. Provide a mechanical backup system or redundancy to accommodate power failures for all electric control systems.

D. Redesign secondary vehicle controls (light switches, air-conditioning control, ignition switch, etc.) to bring them within the space envelope and render them operable by disabled hands.

V. Information Processing:

Establish a centralized information and demonstration resource center, with professional staffing, which will:

A. Maintain a list of available equipment and standardized vehicle modifications.

B. Maintain a showroom of representative and functional equipment.

C. Provide technical evaluation and dissemination of applicable technology.

D. Provide a conduit of access to design and assessment from disabled consumers.

E. Interface on an advisory and influence basis with legislative and regulatory groups.

F. Maintain a central data file on:

1. population
2. characteristics of disease or injury types
3. vehicle configurations
4. equipment evaluations
5. engineering data

6. local licensing requirements and trends

7. standards on equipment

8. employment profiles

G. Provide a constant efflux of:

1. terminology

2. resource materials to special interest groups

3. manuals, handbooks, and orientation material

4. informed statistics for the media

5. support materials for lobby and executive representatives

VI. Assessment, Education, and Training:

A. Initiate the assessment of a candidate for driver training with, but not limited to, an in-depth physical and psychological examination to determine his capacity for performing the physical and decision-making tasks of driving.

B. Develop a clinical team approach to assessment which would include the physician, therapists, engineers, and the candidate himself.

C. Enhance assessment by using a specially equipped training vehicle with dual controls on an out-of-traffic closed driving range.

D. Establish a single, centralized (or several regional) assessment, education, and training center to:

1. pool DOT, RSA, and VA efforts

2. develop a minimum standard assessment and training format

3. develop a standard adaptive equipment prescription format

4. develop and execute trainer certification

5. help government agencies update and develop licensing standards

6. maintain an up-to-date sample of special vehicle adaptations and equipment
7. publish a source book
8. conduct periodic workshops and refresher seminars for driver educators - trainers
9. supply the user media with up-to-date evaluations of new equipment

E. Establish a periodic review system for the disabled driver to determine his continued ability to perform as a driver.

VII. Vocational Impact:

A. Study the benefits of personal transportability on the economic independence of a disabled person.

B. Investigate the employment capabilities directly tied to driving a vehicle (chauffeurs, delivery persons, truckers) by disabled persons.

C. Research and design a total mobility concept which would indicate adapting the wheelchair to the work situation.

SECTION IV. ATTACHMENTS

PROGRAM

Attachment A

Personal Licensed Vehicles for the Disabled
Skyline Inn
Washington, D.C.
June 14-17, 1976

Richard M. Herman, Chairman
J. Raymond Pearson, Co-Chairman

Monday, June 14		Hall of States
10:00 a.m.	Purpose and Goals of Workshop	Herman, Pearson
10:15	Interest and Role of: Veterans Administration	Vaughn, Shultz, Chase, Staros
10:35	Rehabilitation Services Administration, DHEW	Garrett
10:45	Department of Transportation	Laster
10:50	Consumer Groups	Ross
11:00	Exhibition and Demonstration of Vehicles, Adaptive Aids and Training Devices (Hall of States and Parking Lot)	Staros, Peizer, Reichenberger
Tuesday, June 15		**Hall of States**
8:30 a.m.	Plenary Session (Panel Assignments)	Herman, Pearson, Wilson
9:30-- 3:00 p.m.	Panel Sessions	Panel Leaders
Wednesday, June 16		**Hall of States**
8:30 a.m.	Plenary Session	Herman, Pearson
9:30-- 3:00 p.m.	Panel Sessions	Panel Leaders
Thursday, June 17		**Hall of States**
8:30 a.m.	Consolidated Panel Reports and Discussion	Panel Leaders
11:30-- 12:00 noon	Concluding Remarks	Herman, Pearson

Attachment B

LIST OF PARTICIPANTS

Workshop on Personal Licensed Vehicles
June 14-17, 1976

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Attachment C

MOBILITY EQUIPMENT DISPLAYED

EQUIPMENT	SUPPLIER AND ADDRESS
Commercially Available Modified Vans:	
Braun	Braun Corporation 1014 South Monticello Winamic, Indiana 46996
Compass	Compass Industries, Inc. 715 Fifteenth Street Hermosa Beach, California 90254
Drive-Master	Drive-Master Corporation 61-A N. Mountain Avenue Montclair, New Jersey 07042
Helper	Helper Industries, Inc. 832 N.W. First Street Fort Lauderdale, Florida 33311
Motorette	Motorette Corporation 6014 Reseda Boulevard Tarzana, California 91356
Roycemobile	Royce International, Ltd. Department AL 4345 South Santa Fe Drive Englewood, Colorado 80110
Scott	Mobility Engineering and Development, Inc. 15936 Blythe Street Van Nuys, California 91406
Sevier	General Teleoperators, Inc. P.O. Box 3584 Los Amigos Station Downey, California 90242
Speedy Wagon	Speedy Wagon Sales Corporation 2237 Harvester Road St. Charles, Missouri 63301

EQUIPMENT	SUPPLIER AND ADDRESS
Servo Systems:	
2-degree-of-freedom servo systems:	
CCI-Harden	Creative Controls, Inc. P.O. Box 412 Birmingham, Michigan 48012
3-degree-of-freedom servo systems:	
Scott	Mobility Engineering and Development, Inc. 15936 Blythe Street Van Nuys, California 91406
Sevier	General Teleoperators, Inc. P.O. Box 3584 Los Amigos Station Downey, California 90242
Lunar Rover	Southwest Research Institute 8500 Culebra Road P.O. Box 28510 San Antonio, Texas 78284
Special Mobility Systems:	
Advanced Wheelchair	National Welded Products 2900 Spring Street #6 Redwood City, California 94063
Chair-E-Yacht	Chair-E-Yacht P.O. Box 231 Shoshoni, Wyoming 82649
Everest & Jennings Mark 20 Power Cart	Everest & Jennings 1803 Pontius Avenue Los Angeles, California 90025
Indoor/Outdoor Wheelchair	General Teleoperators, Inc. P.O. Box 3584 Los Amigos Station Downey, California 90242
Para-cycle	The Benz Corporation Post Office Box 5703 San Jose, California 95129

EQUIPMENT	SUPPLIER AND ADDRESS
Permobil	Permobil Box 90 86100 Timra Sweden
Steven Motorized Wheelchair	Steven Motor Chair Co. 120 North Gunter Siloam Springs, Arkansas 72761
Voyager	Voyager, Ltd. P.O. Box 1577 South Bend, Indiana 46634

I.M.P. BY FORD MOTOR COMPANY

Attachment D

ABSTRACT

Abstract of the paper presented at the "Workshop on Personal Licensed Vehicles for the Physically Disabled", held July 14/17, 1976, in Washington, D.C., by Mr. George H. Muller, Manager, Concepts and Features Department, Car Research Office, Ford Motor Company, Dearborn, Michigan 48121.

The paper generally addressed itself to the disabled driver or passenger who must use a wheelchair to move about at home and at work and must interface with, and use, unaided, a passenger car to assure his transportation between home and places of education, work and social functions or recreation.

A synopsis is given of the available demographic data stressing not only the need of the approximately 100,000 disabled drivers who do drive regularly, principally to work, but also bringing to the fore the possibilities currently untapped that may be offered to a potentially larger number who are immobile. Their lack of mobility may be caused by any one of the following: Inadequacy of current specialty equipment including wheelchairs, lack of information on the accomplishments of others and related fear of driving with modified passenger cars, and in many cases difficult and uncomfortable experience when interfacing with private or public facilities, including motels, hotels, and 19 million restrooms.

The paper then addressed itself to the various concepts that were considered in order to overcome the difficulties encountered by the handicapped in general seeking mobility interface with the existing environment. The author explained a position generally not favored by national organizations; he does not propose to modify at great expense the existing buildings, facilities and passenger cars for the chance occurrence of interfacing with 10,000 to 15,000 handicapped using wheelchairs who each year add themselves to the 100,000 enjoying increased and easier mobility. Instead, changes are proposed to the equipment used by the handicapped, particularly the wheelchair, to meet all mobility requirements, leaving structures, except for access ramps, and vehicles essentially unchanged.

Through experience, close work and evaluation with a dozen handicapped volunteers which is described in the paper, design specifications were established in order to establish overall requirements not only for a wheelchair but also for minor additions or substitutions to provide vehicle adaptive equipment to existing automobiles in order to assure improved mobility. Interface with buildings and structures and their multiple restrictions is also improved. The paper was illustrated through slides and enhanced by two short 2-minute movies stressing in detail the main requirements that must be met and demonstrating typical improved equipment in operation.

Finally, alternate plans were submitted and recommendations were given in the interest of marketing the new products in the most convenient and effective manner.

DEMOGRAPHIC SYNOPSIS

Data triangulated from automotive hand control manufacturers, a 1969 Stanford study and projections, and 1958/59, 1964, 1969, 1971, 1972 DHEW studies.

	Total Population			Yearly New Additions
	In Wheelchairs	Braces & Crutches	Total	
CURRENT				
Handicapped Drivers Using Hand Controls	100,000	25,000	125,000	15,000
Handicapped Passengers Driven in Passenger Cars	20,000	10,000	30,000	3,500
Subtotals	120,000	35,000	155,000	18,500
POTENTIAL	100,000	30,000	130,000	12,000
Total With Potential				30,500
MEMO: All U.S.A. & Canada Wheelchair Population	800,000	---	---	98,000

Approximately 12,000 to 15,000 individuals (including 3,500 veterans) join each year the ranks of drivers using wheelchairs. The total may reach 30,500, including passengers using wheelchairs.

NOTE: This data was used in part to establish with other Workshop participants a "Motor Vehicle Disabled Driver Mobility Requirements Matrix".

REFERENCES: DHEW - NCHS Paper Nos.: Series B - No. 27
Series 12 - No. 11
Series 10 - No. 78
Series 10 - No. 92
Series 10 - No. 96
Series 10 - No. 87

DAILY HIGH FREQUENCY DIFFICULT WHEELCHAIR INTERFACES

	TYPICAL DAILY OCCURRENCES
• GOING THROUGH DOORS, OPENINGS, ARCHWAYS AT HOME AND/OR AT WORK, ALSO IN SUPPORT OF EVENTS LISTED BELOW.	30 TO 40
• CLIMBING CURBS OR STEPS, OR MAKING DETOURS TO RAMPS	15 TO 20
• GOING TO BATHROOM — COMMODE INTERFACE	7 TO 10
• GETTING IN AND OUT* OF BED/SOFA/EASY CHAIRS	4 TO 6
• GETTING IN AND OUT* OF CAR	4 TO 6
• NEED FOR CLEAN HAND DRIVE (NO TIRE RUBBING)	4 TO 6
• NEED TO USE "ORTHOPEDIC" CUSHION	CONTINUOUS

* "IN" COUNTS FOR ONE, SO DOES "OUT."

I.M.P.
WHEEL CHAIR REQUIREMENTS – SUMMARY

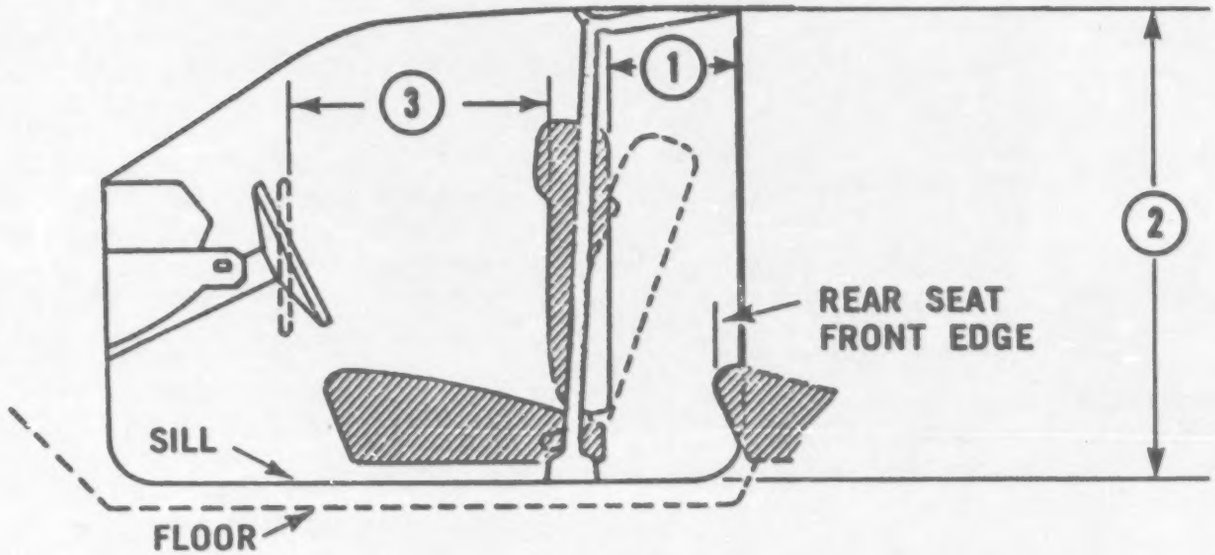
	PACKAGE (INCHES)						WEIGHT — BASE MODEL (LB.)	
	MAXIMUM WIDTH		HIP	MAX.	OVERALL LENGTH		I.M.P.	OCCUPANT
	OPEN	SHUT	ROOM	HEIGHT	OPEN	SHUT	CHAIR	MAX.
FORD SPECS.	21.5 a/	10.0" "HARD" 11.5" "SOFT"	17.5	30.0	49.0	36.0	30	220
1974 BARRIER "FREE"	25.0	NA	NA	36.0	42.0	NA	NA	NA
INDUSTRY PRACTICE (74-75)	28/29	10/12	17/18	34/36	42/46	42	42/46	200/250 ESTIMATED
PURPOSE (INTERFACE)	BUILDING DOORS, RESTROOM DOORS	ALL CARS	AIR CARRIER, COACH SEATING	CAR DOOR OPENING HEIGHT	LEG COMFORT	SMALL CARS	STOWAGE EFFORT	90% POPUL.

NOTE:

a/ INCLUDING L.H. & R.H. INTEGRAL BRIDGES WITH DESK INDENTATION — ASSUMES INFLATED HEAVY-DUTY TIRES.

b/ ADD 2.5 IN. TO THE OVERALL CHAIR HEIGHT FOR CLEARANCE PURPOSES WITH THE CAR DOOR APERTURE BECAUSE OF UNFAVORABLE TILT, DURING STOWAGE ON RETRIEVAL.

TYPICAL PASSENGER CAR DOOR OPENING FOR I.M.P. WHEELCHAIR RETRIEVAL



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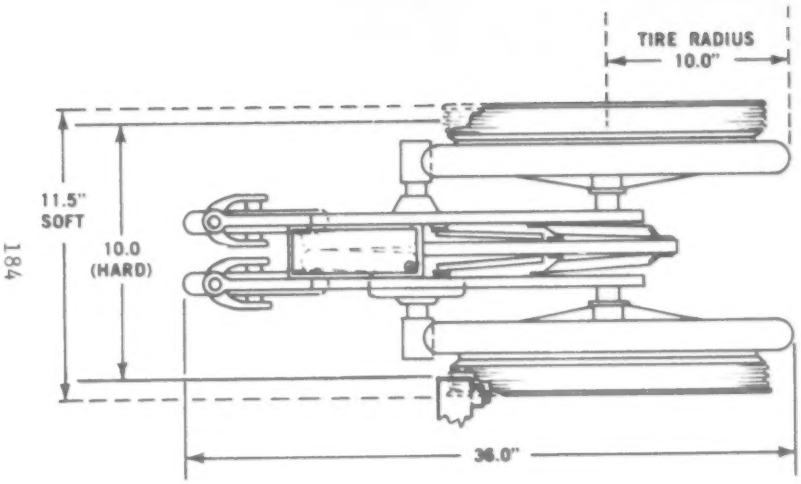
①	ALL DIMENSIONS IN INCHES	1976 TARGET FORD/A.S.E. WHEELCHAIR	1977 PINTO & BOBCAT BUCKET	1977 MAVERICK SPLIT BENCH	1977 LTD II SPLIT BENCH	1977 FIESTA (NAAO) BUCKET
	WHEELCHAIR RETRIEVAL APERTURE WHEELCHAIR WIDTH (SHUT)	11.0	11.0	12.5 (EDGE) 11.0 (INSIDE)	11.0	12.4
②	VERTICAL APERTURE	30.0	34.6	33.5	36.4	34.1
③	SEAT BACK FACE TO STEERING WHEEL (FLEXED OR TILTED)	18.0	20.0	17.0	18.2	18.0
	STATUS	—	OK	TIGHT	OK	OK

I.M.P.
OTHER SPECIAL REQUIREMENTS

	PACKAGE DATA (INCHES)			
DOCKING AND BRIDGE	DOCKING LOCK HEIGHT VARIATIONS	BRIDGE WIDTH (FORE/AFT)	BRIDGE LENGTH OPEN	"D" POINT SEATING HEIGHT
	3.5 (MIN)	14.0 (MIN)	18.0	17.5 TO 18.0

	COMMODE FUNCTION		BATH-TUB FUNCTION
BATH ROOM	REAR WHEEL SPACING (OPEN) (RIM & RIM FLANGE)	FREE DEPTH BETWEEN REAR WHEELS	(TUB ADAPTER DATA) BRIDGE HEIGHT
	15.5 MIN.)	16.0 TO 16.5 (MIN.)	20.0

I.M.P.
POWERED COLLAPSIBLE WHEELCHAIR



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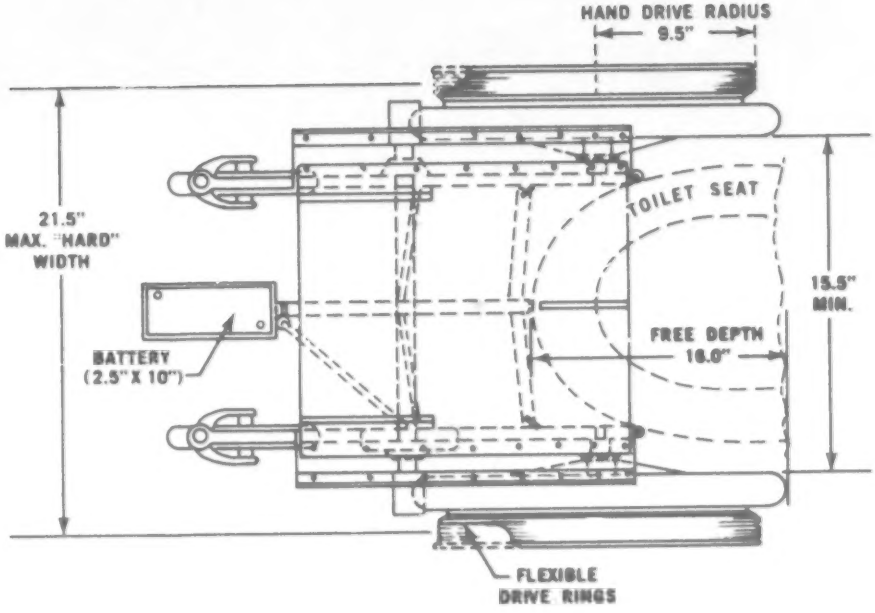

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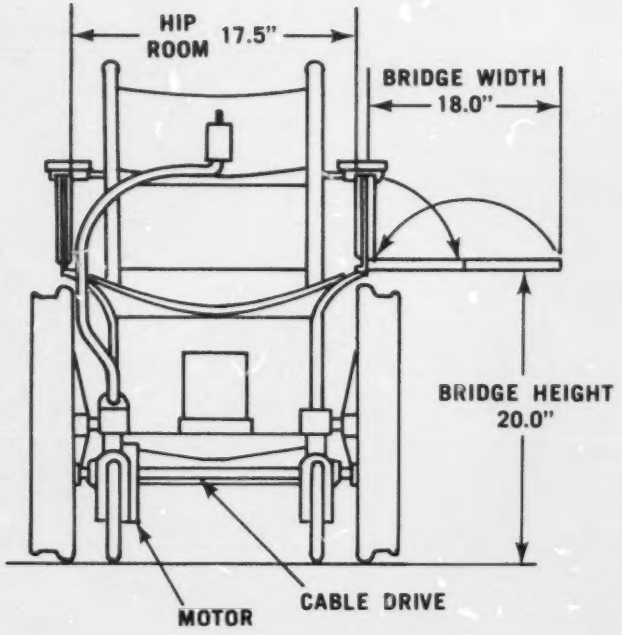
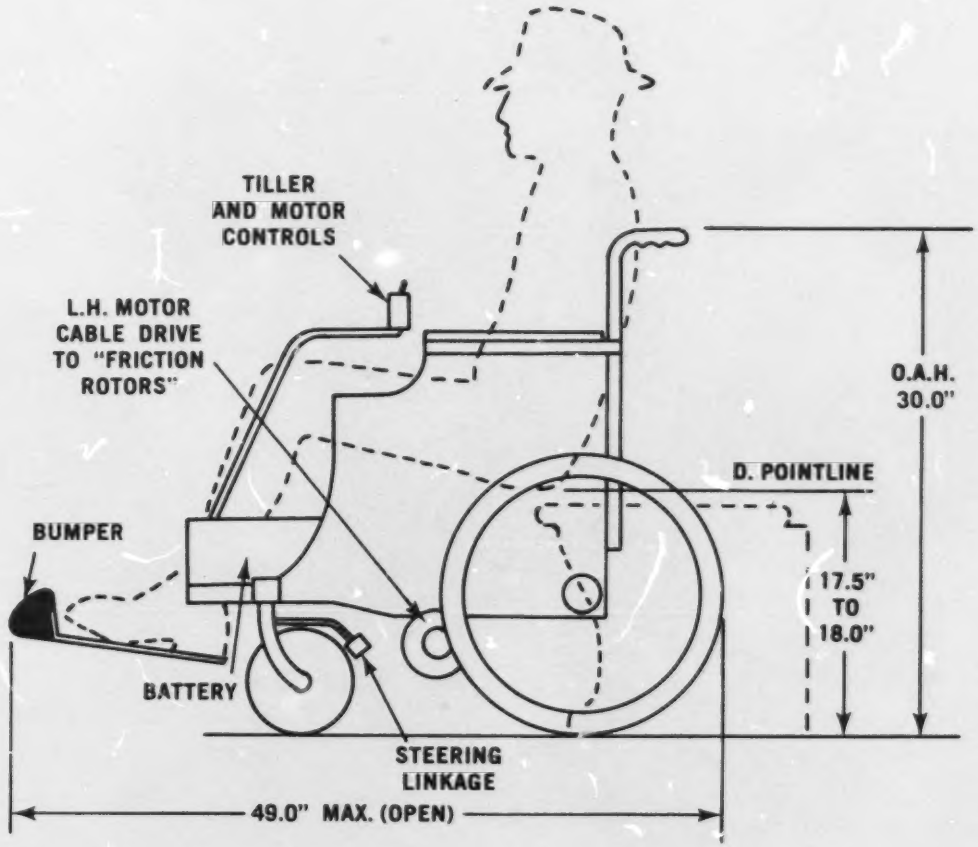
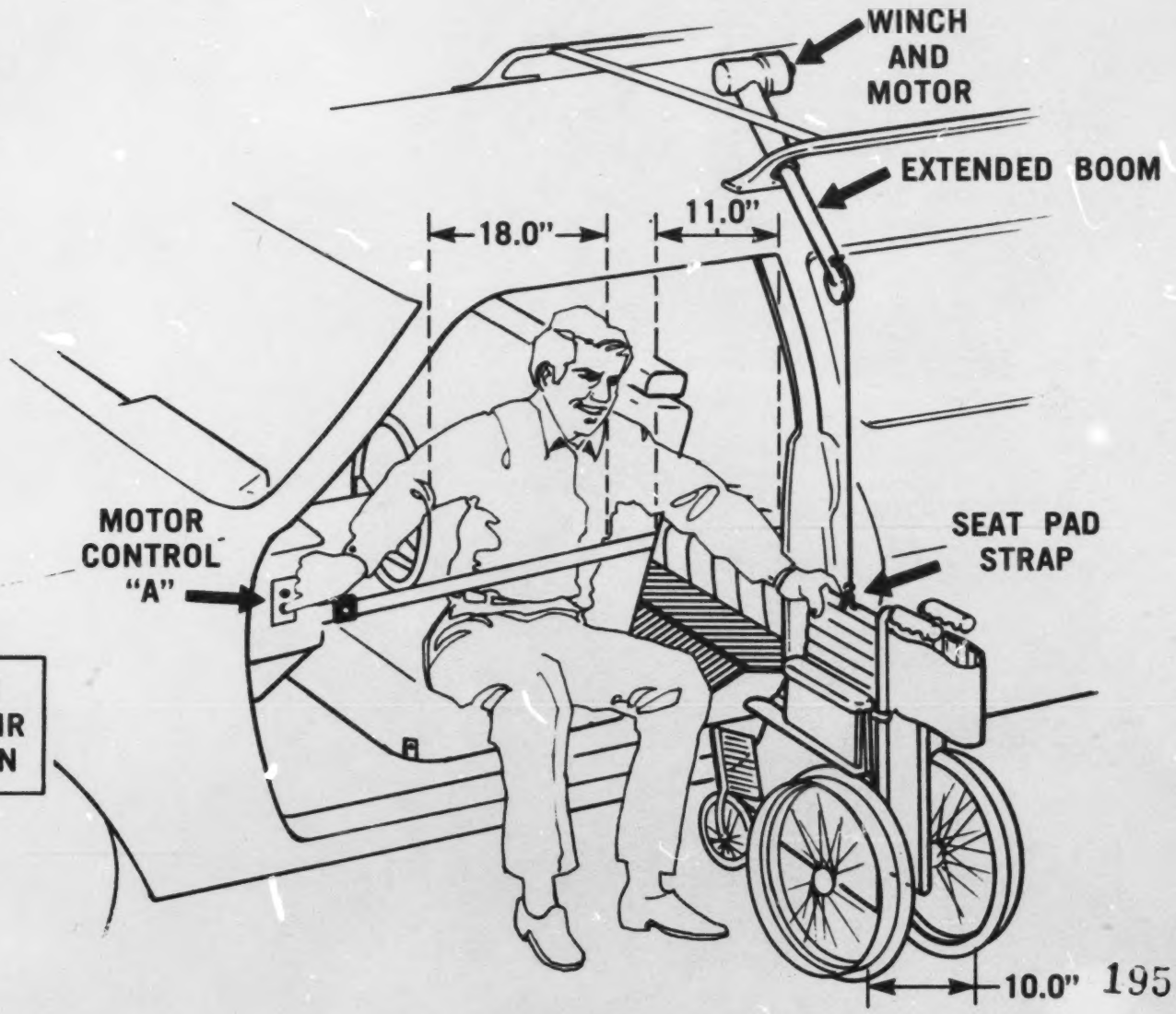
I.M.P.
POWERED COLLAPSIBLE WHEELCHAIR





RETRACTABLE BOOM AND POWER WINCH



TETHER WINCH IN TENSION WHEELCHAIR IN CLOSED POSITION

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MOTOR VEHICLE DISABLED DRIVER MOBILITY REQUIREMENTS MATRIX

TYPE OF DISABILITY	APPROXIMATE POPULATION SIZE (1978)		INTERFACE WITH VEHICLE			MOBILITY AID		IN-CAR SAFETY RESTRAINTS	SPECIAL DRIVING CONTROLS (BEYOND POWER SEAT, STEERING, BRAKE AND AUTOMATIC TRANSMISSION)		OTHER CAR ADAPTIVE EQUIPMENT	SPECIFICATIONS		CONFORMITY TO SPECIFICATIONS	OTHERS
	ACTUAL NUMBER DRIVING	TOTAL POTENTIAL (INCL. ACTUAL)	ACCESS	EGRESS	SECURITY	WHEELCHAIR	OTHER			PRICE TO USER $		SELF-IMPOSED	GOVERNMENT AGENCY	• INSTALL • MAINTAIN	
MAJORS															
NO UPPER LIMB MOBILITY (BI-LATERAL UPPER)	1000	2000	• WALK • EXTERIOR PRESSURE ACTUATORS • FOOT DOOR SLAM —	• INTERIOR PRESSURE ACTUATORS • KICK DOOR OPEN AND SHUT	• ELECTRONIC CONTACT LOCK — (MULTI COMBINATION)	NOT REQUIRED	NONE	SYMMETRICAL HARNESS SYSTEM (IN PLACE THROUGH FOOT OPERATION)	• LEFT FOOT OPERATED STEERING WHEEL AND SIGNALS — USE SLIPPER OR STRAPS ON SHOE • RIGHT FOOT SHIFT	1000 * TO 3000	• RIGHT HAND ACCESS — (NO HIGH TUNNEL OR SHIFT LEVER IN WAY IF POSSIBLE) USE 4-WAY POWER BENCH SEAT (CONVENTIONAL)	NA	NA	NA	
RIGHT HAND UPPER AND LOWER RIGHT (AMPUTEES OR OTHER)	3000	29,000	CONVENTIONAL OR SEE PARA —	CONVENTIONAL OR SEE PARA —	CONVENTIONAL	WHEEL CHAIR FOR SOME	BRACES FOR SOME	CONVENTIONAL	• 8 O'CLOCK SPINNER AND SHIFT LEVER EXTENSION • GAS PEDAL LEFT OF BRAKE PEDAL	100 * TO 200	SAME AS ABOVE PLUS • EXTENDED POWER SEAT TRACK • UP-DOWN MANUAL SEAT ADJUSTMENT	NA	NA	NA	
LEFT HAND UPPER AND LOWER LEFT (AMPUTEES OR OTHER)	3000							CONVENTIONAL RELOCATED WITH RIGHT HAND DOOR ANCHOR	• 4 O'CLOCK SPINNER — • BIDIRECTIONAL LEVER EXTENSION • ELECTRIC MANUAL EMERGENCY BRAKE	100 * TO 200		NA	NA	NA	
DIAGONAL	3000							CONVENTIONAL OR RELOCATED	COMBINATION OF ABOVE			NA	NA	NA	
PARAPLEGICS AND LOWER AMPUTATION —	78,500	180,000	• WHEEL CHAIR • 2 DOOR • LARGE DOOR W / 89° OPENING — PINTO • POWER WHEELCHAIR FOR SOME	SAME AS ACCESS IN REVERSE	CONVENTIONAL	• WHEEL CHAIR • WITH BRIDGE FOR SOME • LAP BELT • POWER OPTION — 30% APPROX.	WALKERS FOR PARAPLEGICS	CONVENTIONAL	• 3 TYPES OF HAND CONTROL — • PUSH / PULL • PUSH - TWIST • PUSH - RIGHT ANGLE SWING OR • SERVO ASSIST • HARDEN SYSTEM • CRUISE CONTROL • STEERING WHEEL SPINNER • HAND - EMERGENCY BRAKE	450 * 1000 ** ??	CAR • EXTENDED POWER SEAT TRACK • SAFETY STRAP (DOOR APERTURE) • CHAIR PLATFORM (FOLDING) • POWERED AND RETRACTABLE BOOM WINCH • BENCH SEAT (PREFERRED) • COLUMN SHIFT (PREFERRED) VAN • LIFT GATE • EXTENDED POWER SEAT TRACK • LOWER STEERING EFFORT — (POW. STEER VALVE)	RE-LONCHE PROPOSED FORD 1979 WHEEL CHAIR AND CAR DOOR APERTURE & SEAT SPECS. V.A. YES • WHEEL CHAIR • HAND CONTROLS		NA	
• VETERANS															
• CIVILIANS WITH CARDIAC INVOLVEMENT	?														
RIGHT HAND HEMIPLEGICS	8000	15,000	WALK	WALK	CONVENTIONAL	NOT REQUIRED	BRACES CRUTCHES CANES	CONVENTIONAL	SEE RIGHT HAND AND LEFT HAND UPPER ABOVE	100 * TO 200	• SOME OF ABOVE PLUS • TELESCOPIC ACCESS HAND RAIL (EXTENDING OUTWARD FROM 'B' PILLAR)	NA	NA	NA	
LEFT HAND HEMIPLEGICS	2000	11,000													
OTHERS															
QUADRIPLEGICS	3500	5000	VAN WITH LIFT OR HELPER PERSON	LARGE HEAD DOOR SET	COMBINATION WHEEL CHAIR AND DRIVER SEAT ASSEMBLY (SEE PARA)			SYMMETRICAL HARNESS SYSTEM	• CRUISE CONTROL • PUSH / RIGHT ANGLE WITH WRIST SUPPORT • HARNESS (ALTERNATE) • ELECTRIC HAND BRAKE	450 * 1000 **	1. SPECIAL CONTROL KNOB ADAPTORS, ETC 2. SEE PARA 3. PLUS STEERING CUFF	NA	NA	NA	
BRAIN DAMAGE • ACQUIRED • CONGENITAL	NONE KNOWN	? UP TO 25,000	SOME EQUIPMENT AVAILABLE — IMPROVED PATIENT EVALUATION AND RESEARCH REQUIRED												
BEHAVIORAL • CHEMICAL • OTHER															
TOTALS	100,000	250,000													
ADDED POTENTIAL	—	150,000													

NOTE * APPROX. AMOUNTS — U.V. PRACTICE ** ESTIMATE

J. SPIVAK AND S. H. DIALLER 09/1978

OTHERS:
- SPECIFIC DISPENSATIONS TO CAR MANUFACTURER
- SPECIFIC PRODUCT LIABILITY LIMITATIONS FOR MANUFACTURER INSTALLED REMED SPECIALIST — SERVICE ENGINEERS

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Attachment F

ADAPTIVE AUTOMOTIVE EQUIPMENT MANUFACTURERS IN COMPLIANCE WITH VA REQUIREMENTS (FEBRUARY 1976)

1. Blatnik Precision Controls, Inc.
   1523 Cota Avenue
   Long Beach, California 90813
   (213) 436-3275

2. Drive-Master Corp.
   61 North Mountain Avenue
   Montclair, New Jersey
   (201) 744-1998

3. Ferguson Auto Service
   1112 North Sheppard Street
   Richmond, Virginia 23230
   (804) 358-0800

4. Gresham Driving Aids
   P.O. Box 405
   Wixom, Michigan 48096
   (313) 624-1533

5. Handicaps, Inc.
   4345 South Santa Fe Drive
   Englewood, Colorado 80110
   (303) 781-2062

6. Hughes Hand Driving Controls, Inc.
   Tevis Bridge Road
   Lexington, Missouri 64067
   (816) 259-3681

7. Kroepke Kontrols, Inc.
   104 Hawkins Street
   Bronx, New York 10464
   (212) 885-1547

8. Manufacturing & Production Services
   2932 National Avenue
   San Diego, California 92113
   (714) 292-1423

9. Mross Inc.
   Star Route Box 42
   Elizabeth, Colorado 80107
   (303) 646-4096

10. Nelson Products
    5690-A Sarah Avenue
    Sarasota, Florida 33577
    (813) 924-2058

11. Smith's Hand Control
    1472 Brookhaven Drive
    Southaven, Mississippi 38671
    (901) 743-5959

12. Thompson Hand Control
    4333 N.W. 30th Street
    Oklahoma City, Oklahoma 73112
    (405) 946-95[illegible]

13. Trujillo Industries
    5726 W. Washington Blvd.
    Los Angeles, California
    90016
    (213) 933-7469
    (Manufactures steering assists only)

14. Wells-Engberg Co.
    P.O. Box 6388
    Rockford, Illinois 61125
    (815) 874-6400

15. Wright-Way Inc.
    P.O. Box 907
    Garland, Texas 75040
    (214) 278-2676